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Gulf Shrimp Vessels

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Groundfish Fisheries and Research in the Vicinity of Seamounts in the North Pacific Ocean

RICHARD N. UCHIDA and DARRYL T. TAGAMI

ABSTRACT—The trawl fishery over the central North Pacific seamounts expanded rapidly after 1967 when exploratory fishing by Soviet trawlers demonstrated commercial concentrations of pelagic armorhead, Pentaceros richardsoni, *and smaller quantities of alfonsin,* Beryx splendens. *In 1969, Japanese trawlers entered the fishery but developmental problems led to wide catch fluctuations in 1969-71. After 1971, catches stabilized and then peaked at 34,538 metric tons in 1974.*

Hancock Seamounts, within the 200-mile U.S. Fishery Conservation Zone around the Hawaiian Archipelago, were fished in 1972-76 by Japanese trawlers, producing annual catches from 653 to 8,518 metric tons. In 1978-81, U.S. observers accompanied three Japanese trawlers which made six trips to Hancock Seamounts. Observer data indicated that the pelagic armorhead stock had recovered to some extent from the intense fishing prior to 1977. The catch per unit of effort in 1980 and 1981 improved and showed an upward trend.

Introduction

In the central and western North Pacific Ocean, one of the chief topographic characteristics of the ocean floor is the large submarine volcanoes, which were once high islands. Some of these former volcanic islands are now worn down into low, sandy atolls such as Kure Atoll in the Hawaiian Archipelago (Menard and Hamilton, 1963; Carlquist, 1970). However, many others have subsided 0.5 km or more below the sea surface and their summits lack a coral cap. These are the guyots or seamounts identifiable as former islands by their form and by the presence of shallow-water fossils that have been dredged from their summits. By definition, a seamount is an elevation that rises 1,000 m or more from the sea floor and is flat and of limited extent across the summit (U.S. Board on Geographic Names, 1969).

The Hawaiian Archipelago and the numerous seamounts to the north and northwest of the chain are shown in Figure 1. Those to the north are the Musicians Seamounts which have summits that are rather deep, most of them well over 1,650 m below the sea surface. The seamounts discussed in this report lie on the Hawaiian and Emperor Seamount Ridges. The Hawaiian Ridge extends for some 1,350 n.mi. from the Island of Hawaii on the southeastern extremity to Kure Atoll on its northwestern end. The Emperor Seamount Ridge then continues in a northerly direction and terminates at the juncture of the Aleutian and Kurile Islands arc and trench systems (Malahoff and Woollard, 1970).

The 200-mile Fishery Conservation Zone (FCZ) around the Hawaiian Archipelago includes the Northwestern Hawaiian Islands (NWHI), a chain of small islands stretching from Nihoa to Kure Atoll. Surrounding these islands are numerous submerged banks and seamounts, including Hancock Seamounts, which in recent years have been fished by Japanese trawlers under a quota established by the preliminary management plan (PMP)[1] for seamount-groundfish resources.

In October 1976, just 5 months before enactment of the Magnuson Fishery Conservation and Management Act (MFCMA), the Honolulu Laboratory of the Southwest Fisheries Center (SWFC), National Marine Fisheries Service (NMFS), launched an investigation of the marine resources of the NWHI. Because the extent of the investigation was beyond the capabilities of the staff and facilities of any single research agency in Hawaii, the SWFC proposed a cooperative effort with the Hawaii Division of Aquatic Resources (HDAR), Hawaii Department of Land and Natural Resources, and the U.S. Fish and Wildlife Service (USFWS). From the proposal evolved a formal tripartite agreement which, in effect, gave responsibility to the HDAR for the survey and assessment of the inshore fishery resources and to the USFWS for land-associated resources such as sea and land birds. The SWFC assumed responsibility for developing a quantitative fishery survey and assessment of the slope, coastal pelagic, and seamount resources. A short time after the agreement was signed, a fourth agency, the University of Hawaii Sea Grant College Program, became an active participant in the investigation by assuming responsibility for research to fill obvious gaps in the tripartite investigation.

This report reviews the historical de-

[1]Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, California. Final environmental impact statement/ Preliminary fishery management plan. Seamount groundfish fishery resources (pelagic armorheads and alfonsins). NOAA, NMFS, January 1977, 27 p.

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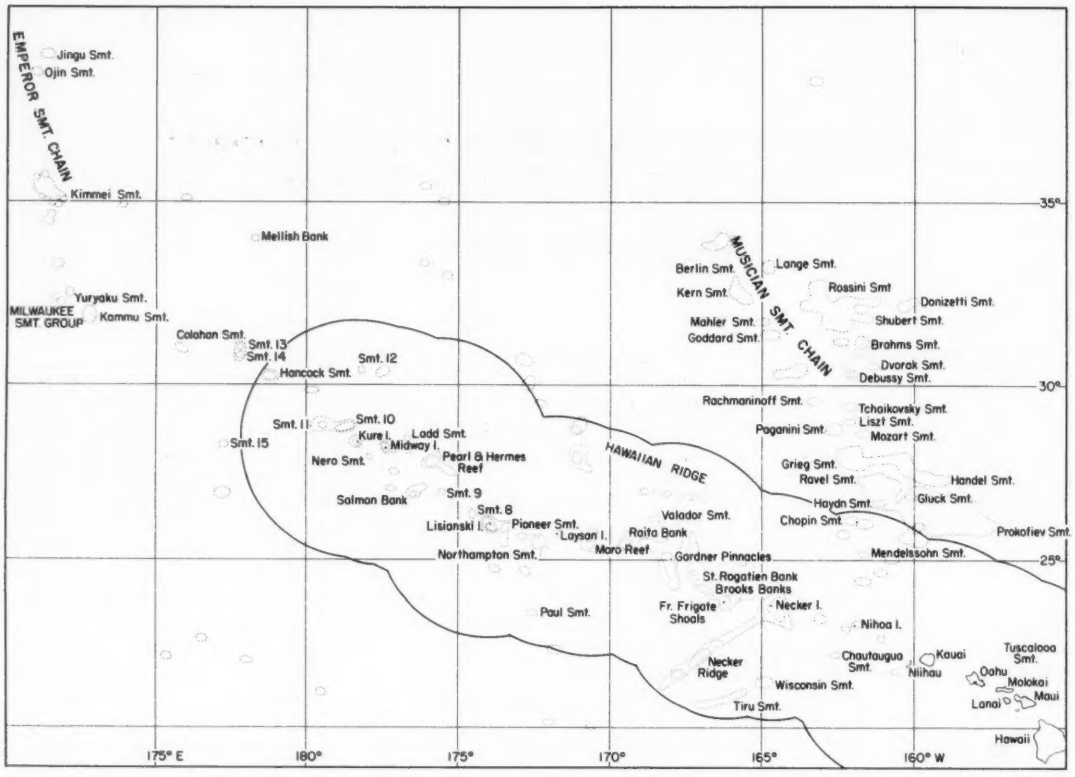


Figure 1.—Hawaiian Archipelago and nearby seamount chains and groups.

velopment of the seamount-groundfish trawl fishery over the central North Pacific seamounts, presents an analysis of the data collected by U.S. observers on Japanese trawlers fishing over Hancock Seamounts in 1978-81, and describes the results of the SWFC's surveys over the seamounts within the FCZ around the Hawaiian Archipelago. An earlier report described the exploratory survey at Hancock Seamounts from October 1976 through May 1979 (Gooding, 1980).

Description of the Fishery

History

The historical development of the seamount-groundfish fishery in the central North Pacific has been described in detail by Chikuni (1970, 1971b), Sakiura (1972), Sasaki (1974), and Takahashi and Sasaki (1977). Until 1967, the seamounts aroused very little interest because most fishery scientists were unaware of the resources associated with them.

The U.S.S.R. was the first nation to commercially exploit the seamount-groundfish resources in this area. In November 1967 a Soviet commercial trawler discovered large concentrations of pelagic armorhead, *Pentaceros richardsoni*, on the Emperor Seamount Chain which led to an almost immediate exploitation of the resource by the Soviet trawling fleet and prompted further exploratory fishing on seamounts closer to the Hawaiian Archipelago including Kimmei Seamount, the Milwaukee Seamount group, and Hancock Seamounts (Sakiura, 1972).

The initial catches of the Soviet trawlers were impressive: As much as 20-30 metric tons (t) were taken in hauls of 10-20 minutes (Sakiura, 1972). The catch rate averaged 5.8 t per half-hour tow in 1968 and doubled to 11.7 t per half-hour tow in 1969. Furthermore, in one 8-month period from December 1969 to July 1970, Soviet trawlers reportedly harvested 133,400 t of pelagic armorhead from the seamounts. A second species of commercial value, the alfonsin, *Beryx splendens*, made up as much as 30 percent of some of the trawl hauls. The Soviet trawlers reported that the thickness of the schools of pelagic

armorhead over the seamounts was as much as 160 m but usually was closer to 30 m. The size of the catches reported by the Soviets, however, was questioned by Sakiura (1972).

In August 1969, Japanese trawlers of 1,500-4,000 gross tons entered the fishery. Their initial effort was mostly exploratory, but they set the stage for full-scale commercial operations by 1972. Frequently, some trawling was conducted by Japanese trawlers en route to and from the Bering Sea and the Gulf of Alaska. To assist in the development of the fishery, Japanese research vessels conducted extensive surveys in 1972 to determine the distribution of pelagic armorhead and alfonsin and their potential for development. They explored the central North Pacific for uncharted seamounts, verified the positions of known seamounts, produced charts on the topography and profile of most of the seamounts, and collected oceanographic data to determine the physical, chemical, and biological characteristics of the waters in the vicinity of these seamounts (Japan Marine Fishery Resource Research Center (JAMARC), 1973; Japan Fisheries Agency, 1974). Additional surveys followed in 1973 and 1974. Results of these surveys showed that many of the seamounts were too deep for effective trawling. Those suitable for trawling were located on the southern end of the Emperor Seamount Chain, beginning with Kimmei Seamount and extending south-southeast to Hancock Seamounts in the U.S. FCZ (Sasaki, 1978).

When first marketed in Japan, the pelagic armorhead met stiff consumer resistance and the fishing firms temporarily suspended trawling owing to poor sales (NMFS, 1975). Extensive advertising and sales promotion, however, boosted market demands. By 1973, consumer demand was on an upward trend and the Japanese trawlers expanded their operations over Milwaukee, Colahan, and Hancock Seamounts, but the catch rates were already declining. In 740 hours of trawling in 1973, the catch rate was 33.8 t per hour, down considerably from the 1972 catch rate of 60.1 t per hour (Takahashi and Sasaki, 1977). A strong surge in demand in early 1975 continued into 1977, but landings remained low (NMFS, 1977).

Historical Japanese Catches

Because the early years (1969-71) of the Japanese seamount-groundfish trawl fishery were exploratory and developmental, annual catches fluctuated widely; 1972 is regarded as the real beginning of the commercial fishery.

The annual catch, trawling effort, and catch per unit of effort (CPUE) of pelagic armorhead for all the major seamounts fished by the Japanese in 1969-76 are given by Takahashi and Sasaki (1977). The Milwaukee Seamount group was by far the most productive, accounting for nearly 55 percent of the 1969-76 catch. Next in importance was Kimmei which produced 17 percent of the pelagic armorhead catches, followed by Colahan, Hancock, C-H (unnamed seamount located between Colahan and Hancock), "others," and Mellish. The relative abundance of pelagic armorhead was highest at Hancock, followed closely by Colahan and C-H (discounting Mellish because of the small effort there). These were followed by Milwaukee, "others," and Kimmei.

From 1969 to 1971, Japanese landings of pelagic armorhead fluctuated widely between 3,280 t in 1969 and 30,047 t in 1970; however, from 1972 to 1976, the catches stabilized, fluctuating between 18,952 t in 1975 and 34,538 t in 1974. Effort, on the other hand, increased from 157 to 2,807 hours during the exploratory phase, dropped to 496 hours in 1972, then rose steadily thereafter to 2,667 hours in 1976, an increase of more than five times during the latter period. The result was that the CPUE declined steadily from the 1972 peak of 60.2 t per hour to 9.7 t per hour in 1976[2] (Fig. 2). Figure 2 also shows the catch statistics (discussed later in greater detail) for three Japanese trawlers that fished Hancock in 1978-81 after the enactment of the MFCMA.

Because Hancock Seamounts fall within the U.S. FCZ, it is of interest to compare the catch and trawling effort over them with the total central North Pacific catch and effort. The Japanese commercial trawling effort at Hancock Seamounts in 1972-76 varied from 24 to 212 hours and averaged 74.6 hours (Takahashi and Sasaki, 1977). Hancock Seamounts received from <1 to 29 percent of the entire central North Pacific trawling effort. Catches made during the same period varied between 653 and 8,518 t and averaged 2,804 t. The landings from Hancock constituted from 3 to 34 percent of the entire central North Pacific seamount landings. Catches at Hancock were usually <7 percent of the total central North Pacific landings, but the 1973 catch was slightly more than one-third of the 25,047 t landed by the Japanese trawlers, because there was a drastic decline in catches that year at Milwaukee Seamount, which normally contributed the largest proportion of the pelagic armorhead catches from the central North Pacific seamounts.

Although the seamount fishery concentrated on pelagic armorhead, a small amount, usually <5 percent of the catch, included a second species of commercial value, the alfonsin. The annual Japanese catches of alfonsin from the central North Pacific seamounts varied widely from 26 to 2,807 t during 1969-71. Between 1972 and 1976, the catches fluctuated from 0 in 1974-75 to 1,726 t in 1976[3]. Overall, from 1969 to 1976, <2 percent of the catches were alfonsin (excluding other miscellaneous species taken by the trawl). Kimmei Seamount was by far the most productive for alfonsin, accounting for about 69 percent of the landings, followed by the Milwaukee Seamount group which produced 24 percent of the landings. The remaining seamounts, all south of Milwaukee (except, perhaps, for some unknown location in the "others" group),

[2]Unpublished data obtained through the courtesy of Takashi Sasaki of the Far Seas Fisheries Research Laboratory, Japan Fisheries Agency, indicated that the catch rates declined 2.4 per hour in 1977 and fluctuated within a narrow range of 0.3 and 0.8 per hour in 1978-81. Trawling effort ranged from 1,631 to 2,642 hours during 1977-81 while total catch varied between 500 and 6,245 t.

[3]Unpublished data from the source cited in footnote 2 indicated that the 1977-81 catch varied between 1,649 and 8,638 t with CPUE fluctuating between 0.7 and 4.8 t per hour. The trawling effort remains the same as noted in footnote 2.

contributed about 3 percent or less of the total landings. Kimmei also had the highest catch rate of alfonsin, 0.6 t per hour, far better than at Hancock which had the second highest catch rate of 0.1 t per hour. The data suggest that the center of abundance of alfonsin in the central North Pacific is near Kimmei whereas that for pelagic armorhead is more to the south near Colahan, C-H, and Hancock Seamounts.

In addition to trawls, alfonsin are caught by bottom longlines. The Japanese bottom longline fishery for this species began on the Milwaukee Seamount group in 1972. At present, virtually nothing is known about this so-called "open fishery" because no permits or licenses are required in Japan. Information provided by the fishing master of the FV *Biko Maru*, a bottom longliner, revealed that the alfonsin resource over the central North Pacific seamounts appears to be declining (Suisan Sekai, 1976). Furthermore, fishing intensity has increased over the years with more Japanese and Korean vessels entering the fishery. The result was that whereas a full load could be obtained in as few as 13 days in previous years, many boats nowadays are not only forced to stay on the grounds longer, but also, to fish for other less desirable species such as rockfish or "akodai," *Sebastes matsubari*, to make up for the lack of alfonsin.

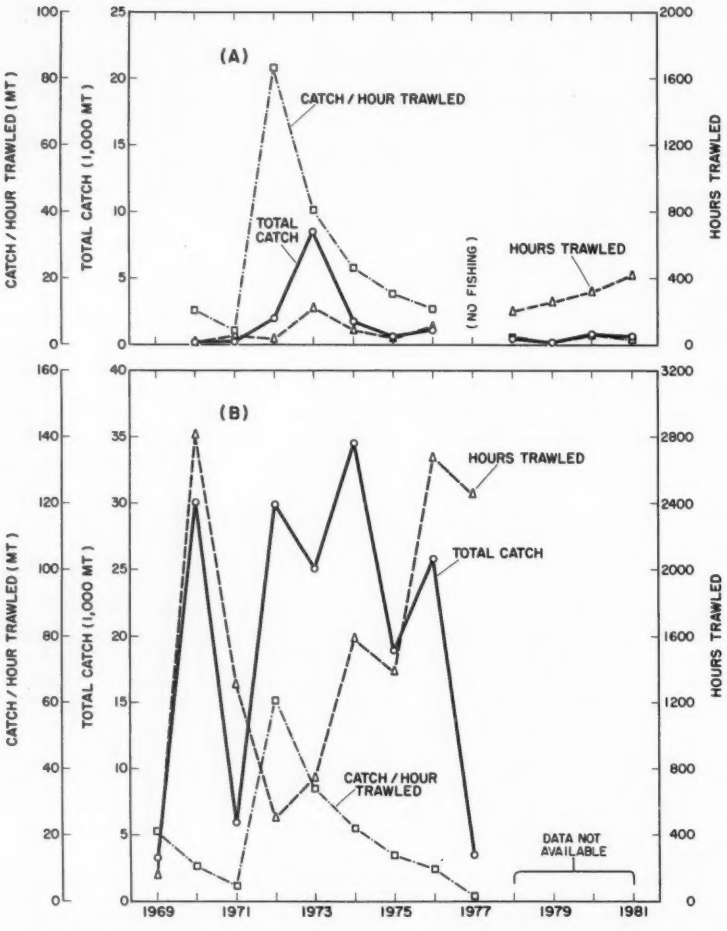


Figure 2.—Catch, hours trawled, and catch per hour trawled in the Japanese trawl fishery for pelagic armorhead over (A) Hancock Seamounts and over all the (B) central North Pacific Seamounts, 1969-81 (data for 1969-76 are from Takahashi and Sasaki, 1977).

Fishery at Hancock Seamounts

Because a fishery management plan (FMP) for pelagic armorhead and alfonsin has not been prepared, temporary measures were set forth in a PMP for the seamount-groundfish fishery resources within the U.S. FCZ around the Hawaiian Archipelago. The regulations temporarily restrict the foreign harvest to a 2,000 t catch quota by trawling or bottom longlining and to 60 vessel-days of effort, and, in addition, establish a licensing procedure for foreign vessels, require the submission of detailed catch and effort data, and placement of U.S. observers on any foreign fishing vessel.

In 1978, an application submitted by JAMARC for a trawling survey at Hancock Seamounts was approved. Since then, two commercial trawlers have received approval to fish at Hancock. Each trip, including the survey conducted in 1978, was accompanied by a U.S. observer who collected detailed data on catch by species and fishing effort, and measured and weighed representative samples of the catch. As time permitted, the observers made observations on food and feeding habits and on gonad condition[4].

[4]Seamount fishery, foreign vessel observer reports, available as Southwest Fisheries Center Administrative Reports at the SWFC Honolulu Laboratory, NMFS, NOAA, Honolulu, HI 96812: T. K. Kazama. 1978. *Ryuyo Maru No. 2* (22 April-3 June 1978). SWFC Admin. Rep. 15H, 10 p. G. C. Evering. 1979. *Aso Maru* (27 May-10 July 1979). SWFC Admin. Rep. H-79-14, 10 p. A. R. Everson. 1980. *Kitakami Maru* (9 August-4 October 1980). SWFC Admin. Rep. H-80-15, 13 p. A. R. Everson. 1980. *Aso Maru* (24-30 September 1980). SWFC Admin. Rep. H-80-16, 10 p. N. T. Shippen. 1981. *Aso Maru* (9-19 June 1981). SWFC Admin. Rep. H-81-4, 8 p. W. B. Barnett. 1981. *Kitakami Maru* (15 August-1 October 1981). SWFC Admin. Rep. H-81-9, 12 p.

Table 1.—Vessel specifications and other statistics of Japanese independent stern trawlers fishing for pelagic armorhead at Hancock Seamounts, 1978-81.

Item	Vessel code A	B	C
Vessel specifications			
Length (m)	56.62	91.60	95.11
Gross ton	549.86	2,961.07	3,608.29
Net ton	215.92	1,501.27	1,968.81
Width (m)	9.20	15.50	16.00
Draft (m)	4.15	6.50	9.80
Engine type	Diesel	Diesel	Diesel
Horsepower	1,500	4,000	3,900
Company/owner	Nippon Suisan, Ltd.	Hokkaido Gyogyokosha	Nippon Suisan, Ltd.
Year commissioned	1966	1967	1964
Home port	Konmon-Ko, Tobata	Tokyo Harbor	Konmon-Ko, Tobata
Personnel (no.)			
Officers	9	10	9
Crew	25	40	41
Total	34	50	50

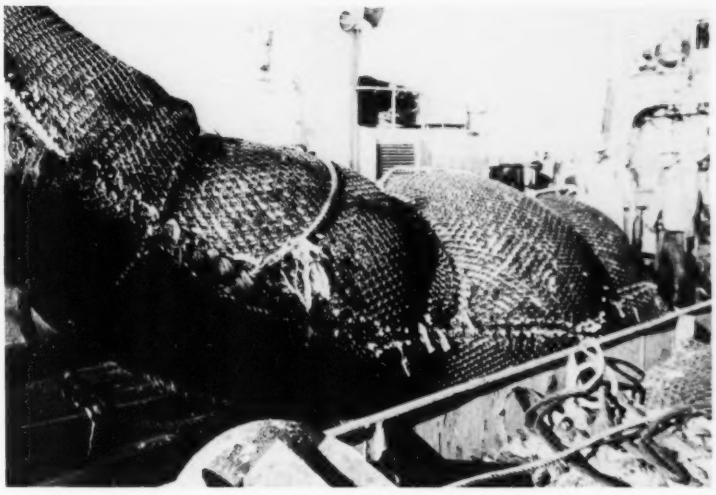


Figure 3.—The cod end of a trawl holding an estimated 7,000 kg of pelagic armorhead and alfonsin aboard Vessel A.

Table 2.—Dimensions of trawl doors and nets used on Japanese trawlers fishing at Hancock Seamounts, 1978-81.

Item	Vessel code A	B	C
Trawl doors			
Shape	Rectangular	Rectangular	Rectangular
Type	Longitudinal	Concave	Longitudinal
Dimensions (m)	2.0×3.0	2.7×4.3	2.2×4.4
Weight (kg)	1,200	4,167	3,100
Nets			
Dandyline (m)	80	150	120
Headrope (m)	28.0	46.0	50.5
Footrope (m)	40.0	59.4	59.0
Vert. opening (m)	6	6	6
Horiz. opening (m)	16	14	22
Warp length (m)	700	1,200	800
Floats			
Number used	30-36	36	46-50
Size (mm)	300-360	360	300-360
Material	Cycolac	Plastic	Cycolac
Shape	Round	Round	Round
Bobbins			
Number used	23	114	35
Size (mm)	530	540-580	530
Material	Rubber; iron	Steel; rubber	Rubber; iron
Shape	Round	Round (car tires)	Round
Mesh size			
Wing (mm)	240	240	180
Square (mm)	180	50/90	150
Belly (mm)	150/120	50/90	150/120; 90
Cod end (mm)	90	90	90

The three trawlers that fished at Hancock Seamounts fell into two of three basic types licensed by Japan (Nelson et al., 1981). Vessel A[5], in the first class of small, independent trawlers, can process the catch into frozen products but cannot produce fish meal and oil. A cod end full of fish caught on Vessel A is shown in Figure 3. Vessels B and C belong to the third class of large freezer trawlers and can produce frozen products as well as fish meal and oil. Vessel specifications and other data are given in Table 1, and description of the trawling gear is given in Table 2. Data on the catch of pelagic armorhead, alfonsin, and other miscellaneous species, number of hauls, total trawling time, average time per haul, and CPUE for all trips to Hancock Seamounts by the three trawlers are given in Table 3. No adjustment was made to standardize the effort unit to account for possible differences in fishing power between the two classes of trawlers. Usually, fishing power is proportional to the gross tonnage of the vessel or to the engine horsepower. However, because neither Vessel B nor C fished the same stock at the same time and place as did Vessel A, comparison of fishing power could not be attempted.

We did find it necessary, however, to adjust the total fishing time for Vessel B to make the effort unit comparable with those of the other vessels. For Vessel B, effort (fishing time) was based on bottom time of the trawl, whereas for Vessels A and C, effort included not only the actual bottom trawling time, but also, the time required for the net to reach the bottom, ascend to the surface, and the turnaround time, because these vessels usually made several passes over the seamount before haulback to empty the net. The turnaround is accomplished by raising the doors completely out of the water and fastening them to the gallows. Then, with the net still in the water and streaming aft, the vessel is turned and positioned for another pass. Admittedly, the measure of effort is not precise. The fact that Vessel B was operating under a charter with JAMARC and that the others were commercial trawlers may explain the discrepancy in the way effort was calculated.

In 1978, the catch rate (adjusted) rose to 2.1 t/hour, then declined in 1979 to 0.7 t/hour, the lowest level at Hancock since fishing began there in 1970. Fish-

[5] To preserve anonymity of the Japanese trawlers that fished over Hancock Seamounts, the vessels are identified with code letters.

Table 3.—Catch of (in metric tons) pelagic armorhead, alfonsin, and other species, number of hauls, total trawling time, average time per haul, and catch per hour of three Japanese trawlers that fished over Hancock Seamounts, 1978-81.

Seamount	Vessel code	Cruise dates	No. of hauls	Total trawling time[1] (min.)	Time per haul (min.)	Catch			Total catch (t)	Catch per hour[2] (t)	Adjusted		
						Pelagic armorhead (t)	Alfonsin (t)	Others (t)			Total trawling time[3] (min.)	Time per haul (min.)	Catch per hour
NW Hancock	B	4/22-6/3/78	39	335	8.6	178.3	1.3	1.8	181.4	32.5	3,822	98.0	2.8
SE Hancock	B	4/22-6/3/78	62	1,662	26.8	228.8	2.4	3.8	235.0	8.5	8,041	129.7	1.8
Total			101	1,997	19.8	407.1	3.7	5.6	416.4	12.5	11,863	117.4	2.1
NW Hancock	C	5/27-7/10/79	57	5,595	98.2	67.6	7.2	23.7	98.5	1.0			
SE Hancock	C	5/27-7/10/79	69	9,570	138.7	67.0	10.7	2.1	79.8	0.5			
K Bank	C	5/27-7/10/79	12	223	18.6	0.9	6.8	0.3	8.0	2.2			
Total			138	15,388	111.5	135.5	24.7	26.1	186.3	0.7			
NW Hancock	A	8/9-10/4/80	59	5,050	85.6	192.9	7.8	4.6	205.3	2.4			
NW Hancock	C	9/24-9/30/80	20	1,925	96.2	40.2	1.6	3.3	45.1	1.4			
SE Hancock	A	8/9-10/4/80	102	9,650	94.6	461.1	23.7	14.1	498.9	3.1			
SE Hancock	C	9/24-9/30/80	14	2,190	156.4	40.5	0.9	4.0	45.4	1.2			
K Bank	A	8/9-10/4/80	2	10	5.0	0.0	0.2	0.2	0.4	2.4			
Total			197	18,825	95.6	734.7	34.2	26.2	795.1	2.5			
NW Hancock	C	6/9-6/19/81	19	1,885	99.2	118.0	8.7	5.8	132.5	4.2			
NW Hancock	A	8/15-10/1/81	155	10,522	67.9	164.7	5.8	8.7	179.2	1.0			
SE Hancock	C	6/9-6/19/81	25	2,250	90.0	259.3	11.2	3.0	273.5	7.3			
SE Hancock	A	8/15-10/1/81	118	9,799	83.0	34.7	8.6	7.2	50.5	0.3			
K Bank	C	6/9-6/19/81	5	70	14.0	12.1	0.0	<0.1	12.1	10.4			
K Bank	A	8/15-10/1/81	34	171	5.0	9.0	3.6	1.3	13.9	4.9			
Total			356	24,697	69.4	597.8	37.9	26.0	661.7	1.6			

[1] Total trawling time on Vessel B based on bottom time of the trawl; those for Vessels A and C based on total time the gear was in the water.
[2] No adjustment made for differences in fishing power of the trawlers.
[3] Adjusted by using data from Vessel C which was similar in vessel characteristics to Vessel B. Adjustment made by calculating an overall time per haul for Vessel A for each of the seamounts fished and multiplying those values by the number of hauls made by Vessel B to obtain the total adjusted trawling time.

ing improved significantly in 1980, particularly for the first vessel trawling at Hancock that year, Vessel A, which had a catch rate of 2.7 t/hour, or nearly four times that of the previous year. Fishing continued to improve in 1981 when the first vessel fishing Hancock, Vessel C, had a catch rate of 5.6 t/hour, or more than twice that for Vessel A in 1980.

In 1980 and 1981, it was obvious that the stock was reduced drastically by the first vessel that fished earlier in the year; the second vessel to arrive on the scene invariably experienced poorer fishing. In 1980, Vessel A, which operated at Hancock Seamounts from 9 August to 4 October, had relatively good catch rates at Northwest (NW) Hancock, Southeast (SE) Hancock, and at K Bank (Table 3). However, Vessel C, which fished after Vessel A from 24 to 30 September, experienced poor catches at NW and SE Hancock. Similarly, in 1981, Vessel C fished Hancock Seamounts from 9 to 19 June and made relatively good catches at NW and SE Hancock and K Bank, indicating that the stock had recovered from the previous year's fishing. When Vessel A arrived at Hancock Seamounts about 2 months later, however, the catch rates once again dropped to very low levels. The poor fishing of the second vessel at Hancock may have resulted from altered behavior or breakup of the pelagic armorhead school brought about by previous fishing activities or by changes in seasonal availability.

Of particular interest is the sharp increase in trawling effort which obviously occurred as a result of placing the pelagic armorhead and alfonsin stocks at Hancock under management (Fig. 2). For example, compared with effort at Hancock during the pre-MFCMA years, 1978 trawling effort reached an estimated 198 hours, or nearly as high as the 1973 peak of 212 hours. Furthermore, the increase in effort continued into 1979-81; effort in 1981 was 412 hours, nearly double the 1973 peak. However, the increase in effort was not accompanied by an increase in total catch, which tended to remain at less than 735 t, considerably below the 1,000 t allocated to Japan and the 2,000 t designated as the total allowable level of foreign fishing (TALFF) as set forth in the PMP.

Pelagic armorhead comprised 73-98 percent of the annual catch from 1978 to 1981. Alfonsin catches varied widely from 3.7 t in 1978 to 37.9 t in 1981, and comprised between 0.9 and 13.3 percent of the annual take in 1978-81.

Research Vessel Survey Results

From October 1976 to April 1981, surveys were conducted on nine cruises of the NOAA ship *Townsend Cromwell* to Seamounts 8, 9, 10, 11, Hancock, Ladd, and Nero (Table 4). These surveys were necessary not only to gather information on the status of the stocks at Hancock Seamounts but also to collect samples and data for studies on geographic distribution, species composition, size composition, food and feeding habits, age and growth, sexual maturity, and spawning.

Bottom Topography

Hancock Seamounts actually consist of two seamounts—one called Northwest (Fig. 4) and the other Southeast—

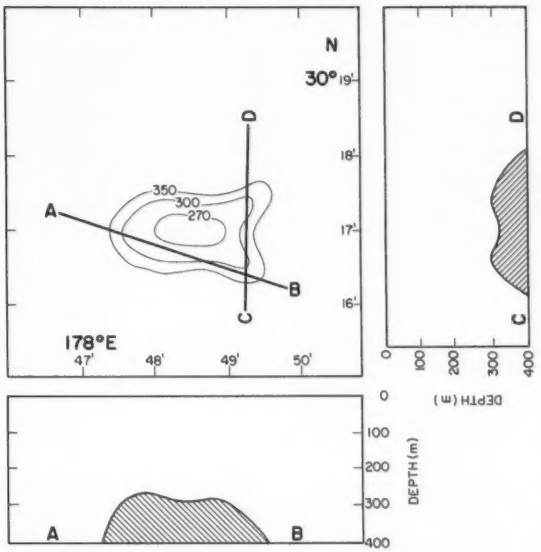


Figure 4.—Bathymetry (m) and lateral profiles (A-B, C-D) of NW Hancock Seamount (from Japan Fisheries Agency, 1974).

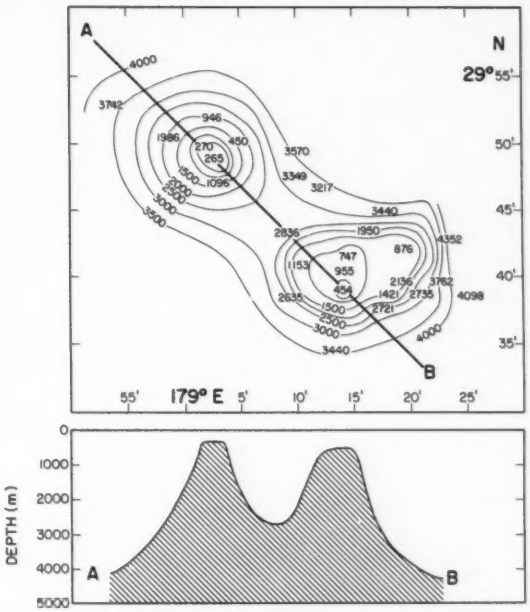


Figure 5.—Bathymetry (m) and lateral profile (A-B) of SE Hancock Seamount (from Japan Fisheries Agency, 1974).

separated by about 34 n.mi. The shallowest point on NW Hancock is 263 m; however, the north-south axis, which is the flat part of the seamount, is very narrow (0.5 n.mi.). Once past the flat portion, the slope is very steep on all sides (Japan Fisheries Agency, 1974).

SE Hancock (Fig. 5) consists of two summits. The summit on the northwestern end (Fig. 6) is flat, narrow, and 265 m at the shallowest area. The flat area extends for 1-2 n.mi., but beyond the 265 m depth contour, the bottom is steeply sloped. The southeastern side of this summit is sloped much more steeply than the northwestern side. The peak on the southeastern end of SE Hancock, also known as K Bank, is about 16 n.mi. to the southeast of the northwestern summit and is relatively rough; the shallowest point is 454 m deep (Japan Fisheries Agency, 1974). The summit of this peak was beyond the trawling depth capability of the *Townsend Cromwell*.

Ladd Seamount, located about 50 n.mi. east-northeast of Midway Islands, is described as rather wide, flat, and about 64 m at the shallowest point (Fig. 7). There are, however, moderate amounts of outcroppings rising from the flat surface making the bottom quite irregular and rugged (Japan Fisheries Agency, 1974). The sides beyond the summit drop off very sharply.

Because of the lack of adequate bathymetric data on Nero Seamount (Fig. 8), located about 38 n.mi. southwest of Midway Islands, an extensive survey of the seamount was conducted between June and November 1980 on the *Townsend Cromwell*. The preliminary smooth-plot boat sheets prepared from the unprocessed and unverified depth data indicated that the shallowest area on Nero Seamount was about 62 m.

Seamount 8, a relatively small seamount about 64 m deep at its shallowest point, is located about 40 n.mi. northwest of Lisianski Island. Seamount 9 is actually a sea peak or pinnacle with a

Table 4.—Seamount surveys of the *Townsend Cromwell*, October 1976-April 1981.

Cruise no.	Cruise period	Survey areas	Operations[1]		
			Trawl	Handline	Trap
76-06	10/12-11/21/76	SE Hancock and Seamount 10	X	X	—
77-02	5/12- 6/27/77	SE Hancock	X	X	—
78-01 (Part II)	1/16- 3/ 9/78	Seamount 11	—	X	X
78-03 (Part II)	9/ 6- 9/24/78	NW Hancock and Seamount 8	X	X	X
79-02 (Part II)	5/ 1- 6/ 6/79	NW and SE Hancock	X	X	X
80-02	3/24- 5/14/80	NW and SE Hancock, and Seamounts 9 and 11	X	X	X
80-03 (Part I)	5/28- 6/27/80	Ladd and Nero Seamounts	—	X	—
80-05 (Part II)	11/ 3-12/16/80	Ladd and Nero Seamounts	—	X	X
81-02	3/18- 4/23/81	SE Hancock and Ladd Seamounts	X	X	X

[1]X = conducted as part of cruise mission; — = not included in cruise mission.

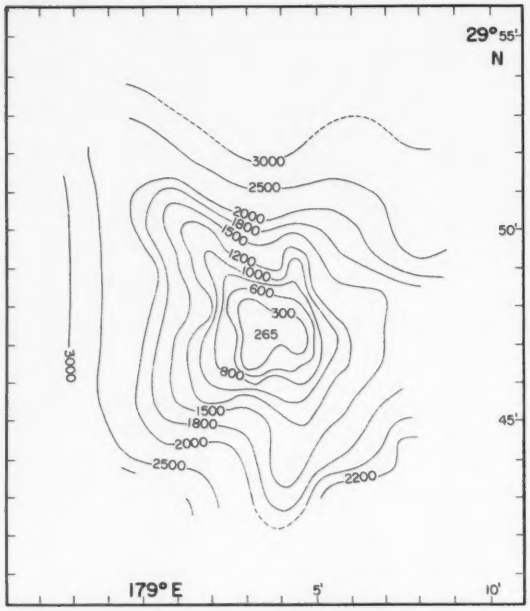


Figure 6.—Bathymetry (m) of the northwest peak of SE Hancock Seamount (from Japan Fisheries Agency, 1974).

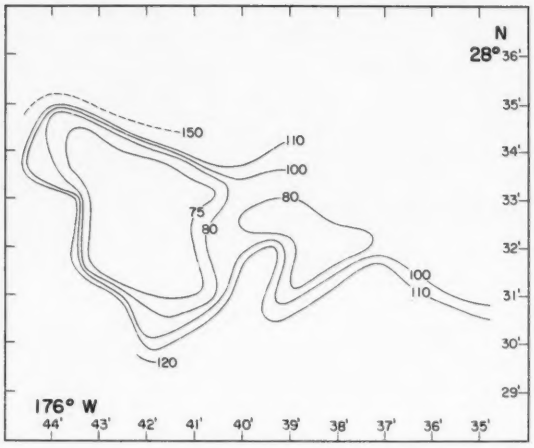
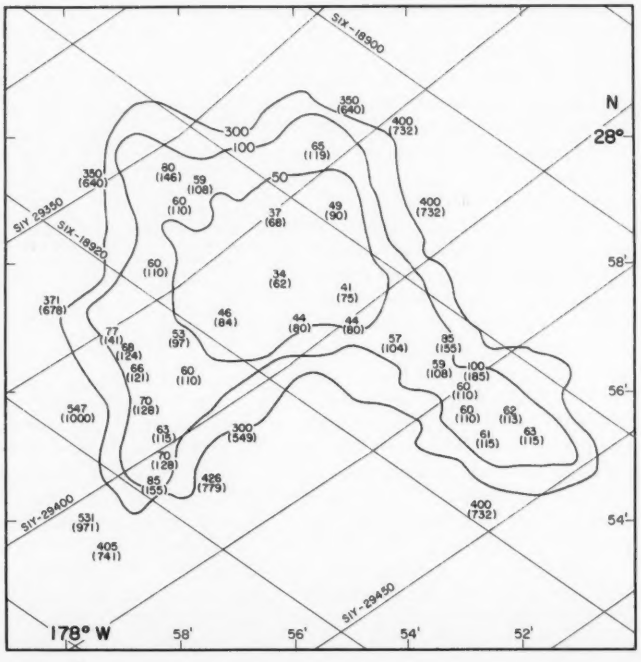


Figure 7.—Bathymetry (m) of Ladd Seamount (from Japan Fisheries Agency, 1974).

Figure 8.—Uncorrected bathymetry in fathoms (number in parentheses denotes meters) of Nero Seamount. Bathymetric chart prepared from soundings made during a hydrographic survey of the seamount by the *Townsend Cromwell* in June-November 1980.



recorded depth of 115 m. About 40 n.mi. northwest of Kure is Seamount 10 which has a reported depth of 329 m. Seamount 11, located 135 n.mi. southeast of Hancock, is reported to average less than 180 m deep. The eastern edge of this seamount is steep, whereas the western side is gently sloped. The summit is very rough.

Sampling Gear

Our primary sampling tool was the bottom trawl operated in an exploratory mode to determine the distribution and composition of the seamount community. Before deploying the trawl at each seamount, acoustic soundings were made to determine its topographic profile. After mapping, the trawl was deployed on the basis of seabed conditions.

Trawling was conducted initially with an 80 percent scale, high-opening Norwegian fish trawl with a 20 m headrope, 25 m footrope, 3.8 cm mesh codend cover, and equipped with 36 cm diameter rollers. In mid-1977, this was replaced with a Noreastern otter trawl

Table 5.—Fishes caught on the *Townsend Cromwell* by trawling over Hancock and other seamounts. The species are listed in descending order of their abundance (total catch) in weight.

Scientific name	Family	No.	Weight (kg)	Scientific name	Family	No.	Weight (kg)
Pentaceros richardsoni	Pentacerotidae	11,546	5,277				
Promethichthys prometheus	Gempylidae	282	172	*Beryx* sp.	Berycidae	1	<1
Beryx splendens	Berycidae	893	147	*Symphysanodon typus*	Lutjanidae	1	<1
Zenopsis nebulosa	Zeidae	269	94	*Parabothus* sp.	Bothidae	1	<1
Squalus blainvillei	Squalidae	61	67	*Laemonema rhodochir*	Moridae	3	<1
Cookeolus boops	Priacanthidae	42	36	*Polymixia* sp.	Polymixiidae	1	<1
Ariomma lurida	Nomeidae	184	29	*Argentina* sp.	Argentinidae	36	<1
Caprodon schlegelii	Serranidae	34	19	*Physiculus* sp.	Moridae	24	<1
Antigonia steindachneri	Antigoniidae	105	5	*Lophiomus miacanthus*	Lophiidae	3	<1
Polymixia japonica	Polymixiidae	35	4	*Isistius brasiliensis*	Squalidae	4	<1
Etmopterus pusillus	Squalidae	6	4	*Symphysanodon maunaloae*	Lutjanidae	5	<1
Antigonia eos	Antigoniidae	124	3.34		Sternoptychidae	11	<1
Ruvettus pretiosus	Gempylidae	1	3.30	*Beryx decadactylus*	Berycidae	1	<1
Macrorhamphosus sp.	Macrorhamphosidae	20	2.78	*Hoplichthys* sp.	Hoplichthyidae	1	<1
Diaphus trachops	Myctophidae	145	2.60	*Plectranthias kelloggi*	Serranidae	5	<1
	Brotulidae	36	2.54	*Astronesthus lucifer*	Astronesthidae	1	<1
Emmelichthys sp.	Emmelichthyidae	17	2.50	*Argyropelecus aculeatus*	Sternoptychidae	2	<1
Chromis struhsakeri	Pomacentridae	19	1.82	*Physiculus grinnelli*	Moridae	1	<1
Physiculus edelmanni	Moridae	18	1.69	*Argyripnus atlanticus*	Gonostomatidae	1	<1
Hyperoglyphe japonica	Nomeidae	7	1.44	*Parapercis roseoviridis*	Parapercidae	2	<1
Conger sp.	Congridae	11	<1	*Peristedion engyceros*	Peristediidae	1	<1
Chascanopsetta prorigera	Bothidae	5	<1	*Antigonia* sp.	Antigoniidae	8	<1
Rhynchocymba nystromi nystromi	Congridae	4	<1		Gonostomatidae	1	<1
	Gempylidae	1	<1	*Callanthias* sp.	Serranidae	9	<1
Parabothus coarctatus	Bothidae	2	<1		Zeidae	14	<1
Peristedion sp.	Triglidae	1	<1		Lophotidae	1	<1
	Bothidae	11	<1		Muraenidae	1	<1
				Symphysanodon sp.	Lutjanidae	2	<1
				Parapercis multifaciata	Parapercidae	1	<1

(Gunderson and Sample, 1980) which was larger than the Norwegian trawl, having headrope and footrope lengths of 27 and 32 m, respectively, 3.2 cm mesh cod-end liner, and rubber bobbins with diameters of 36 and 46 cm. Doors used to spread the two types of trawls were 1.8 × 2.7 m steel V-type, each weighing about 454 kg. A net sonde was attached to the center of the headrope to monitor the depth of fishing.

Day and night tows at an average speed of 2-3 knots were made at each trawl station. Trawling time varied from 5 to 38 minutes but was usually between 15 and 25 minutes depending on the extent of the trawlable area over the seamount. Catches were sorted by species, counted, and weighed. Large catches were subsampled to obtain estimates of the total catch. Biological collections were made for age, growth, and feeding studies.

In addition to the trawl, we used handlines, fish traps, and lobster pots to sample species that would not be caught in a trawl or in areas where trawling was not practical due to the rough summits of some of the seamounts. Handlines, operated with hydraulic gurdies, were fitted with either short terminal rigs of 4-6 incurved hooks (No. 18-32) or long droplines of 20 incurved hooks (No. 16-18). Bait was cut fish or squid. Fish traps, either single or in strings of up to four, measured 1.5 × 0.9 × 0.6 m; the reinforcing steel frame was covered with 2.5 cm square galvanized welded wire mesh. The two types of lobster pots used were the large-mesh pot measuring 0.9 × 0.6 × 0.4 m and covered with 5.1 × 10.2 cm heavy-duty, galvanized wire mesh, and the small-mesh pot measuring 1.1 × 0.8 × 0.5 m and covered with 1.2 × 2.5 cm hardware cloth. Traps and pots, baited with mackerel, had identical conical entrances with outer and inner diameters of 30.0 and 16.5 cm, respectively.

Trawling

The *Townsend Cromwell* trawled over the seamounts during 6 cruises, making 12 hauls at NW Hancock, 7 at SE Hancock, and 1 each at Seamounts 10 and 11[6]. All remaining seamounts, including Ladd and Nero and Seamounts 8 and 9, were sampled with other gear owing either to the roughness or very limited extent of the summit.

We noted a variation in catches and progressively better catches on later cruises. Although most of the trawl hauls were made when the echo sounder showed "fish signs" near the bottom, a few midwater hauls were made when the sounder indicated fish schools at mid-depths, but these hauls were invariably unproductive. Furthermore, because near-bottom trawling over the seamounts was a new operation for the ship's officers, crew, and Honolulu Laboratory scientists, we needed sufficient opportunity to become familiar with the net in the limited time available on each cruise. Therefore, catches made prior to 1979 (*Townsend Cromwell* cruises 76-06, 77-02, and 78-03) may have been greatly influenced by lack of experience and other factors.

The trawl catches, composed of 47 fish species representing 30 families (Table 5), included a diverse variety of species of commercial and noncommercial value. By far the most important was the pelagic armorhead, followed by the snake mackerel, *Promethichthys pro-*

[6]Unlike the Japanese commercial trawlers, the *Townsend Cromwell*'s trawl haul represents only bottom time of the net; therefore, trawling time is not comparable with that of the Japanese trawlers.

Table 6.—Trawl station data and catches of predominant species at Hancock and other seamounts, 1976-81.

Seamount	Cruise	Date	Gear	Time started	Trawling time (min.)	Depth of tow (m)	Distance trawled (km)	Surface temp. (°C)	Bottom temp. (°C)	Catch (kg)						Total catch per hour (kg)	Pelagic armorhead in catch (%)
										Pelagic armorhead	Alfonsin	Mirror dory	Snake mackerel	Horny dogfish	Others	Total		
NW Hancock	78-03	9/8/78	Noreastern	2010	5	283-302	0.6			0.0	0.0	0.0	0.0	0.0	<1.0	<1.0	0.0	0.0
NW Hancock	78-03	9/9/78	Noreastern	1324	10	285-302	0.9	26.6	12.0	0.0	0.1	3.2	0.0	0.0	<1.0	3.3	19.8	0.0
NW Hancock	78-03	9/9/78	Noreastern	2150	15	283-302	1.3	26.6	12.0	69.5	5.7	23.8	25.4	0.0	16.3	140.7	562.8	49.4
NW Hancock	78-03	10/9/78	Noreastern	0925	23	283-302	2.2	26.6	12.0	11.2	0.0	6.9	0.0	0.0	0.6	18.7	48.8	59.9
NW Hancock	78-03	10/9/78	Noreastern	1115	20	283-302	1.8	26.6	12.0	9.2	18.1	9.9	0.0	0.0	<1.0	37.2	111.6	24.7
NW Hancock	79-02	5/4/79	Noreastern	1458	14	269-272	1.3	19.9	15.0	9.8	0.0	0.5	0.0	0.0	0.8	11.1	47.6	88.3
NW Hancock	79-02	5/5/79	Noreastern	1000	17	263-366	1.5	20.9	14.9	3.5	0.0	2.8	0.0	0.0	0.5	6.8	24.0	51.5
NW Hancock	79-02	5/5/79	Noreastern	2116	11	263-293	1.1	20.4	14.2	93.7	4.7	1.0	10.5	0.0	4.1	114.0	621.8	82.2
NW Hancock	79-02	5/5/79	Noreastern	2320	13	258	1.1	20.5	14.9	207.5	1.4	1.4	7.0	8.5	2.4	228.2	1,053.2	90.9
NW Hancock	79-02	5/6/79	Noreastern	0155	12	263	1.1	20.5	14.4	25.1	7.8	4.7	128.2	0.0	0.0	165.8	829.0	15.1
NW Hancock	80-02	4/17/80	Noreastern	1647	11	260	1.1	19.8		[1]4.2	[1]0.2	[2]2.1	0.0	0.0	0.0	6.5	35.4	64.6
NW Hancock	80-02	4/17/80	Noreastern	1934	18	260	1.7	19.7		1,308.8	51.1	4.6	0.0	9.5	2.1	1,376.1	4,587.0	95.1
Total					169					1,742.5	89.1	60.9	171.1	18.0	26.8	2,108.4	748.5	82.6
Average catch per hour										618.6	31.6	21.6	60.7	6.4	9.5			
SE Hancock	76-06	10/29/76	Norwegian	2133	19	265-293	1.8	25.2	13.5	20.9	0.4	0.0	0.0	0.0	4.1	25.4	80.2	82.3
SE Hancock	77-02	5/25/77	Noreastern	2200	20	269-530	1.8			0.0	0.0	0.0	0.0	0.0	<1.0	<1.0	0.0	0.0
SE Hancock	77-02	5/26/77	Noreastern	0848	20	263-311	1.8	21.5	12.6	20.0	0.6	3.6	0.0	0.0	[3]41.9	66.1	198.3	30.2
SE Hancock	79-02	5/6/79	Noreastern	2100	38	256	3.5	19.9	14.8	545.9	7.4	6.8	1.1	43.5	10.8	615.5	971.8	88.7
SE Hancock	80-02	4/16/80	Noreastern	1555	25	258	2.2	20.1		15.4	0.0	14.7	0.0	0.4	0.0	30.5	73.2	50.5
SE Hancock	80-02	4/16/80	Noreastern	2157	23	258	2.2	20.0		1,332.8	44.4	7.4	0.0	0.0	0.0	1,384.6	3,612.0	96.2
SE Hancock	81-02	3/31/81	Noreastern	2230	21		1.8	20.0		1,599.1	4.8	0.6	0.0	3.4	0.5	1,608.4	4,595.4	99.4
Total					166					3,534.1	57.6	33.1	1.1	47.3	57.3	3,730.5		
Average catch per hour										1,277.4	20.8	12.0	0.4	17.1	20.7		1,348.4	94.7
Seamount 11	78-01	2/12/78	Noreastern	1305	12	188-207	0.9	17.2		0.0	0.0	0.0	0.0	0.0	<1.0	<1.0	0.0	0.0
Seamount 10	76-06	10/30/76	Norwegian	2306	30	164-170	2.8	25.1	15.3	0.0	0.0	0.0	0.0	2.0	[3]59.2	61.2	122.4	0.0

[1]Estimated from average weights.
[2]Predominantly driftfish, *Ariomma lurida*.
[3]Predominantly red bigeye, *Cookeolus boops*, and a grouper, *Caprodon schlegelii*.

metheus; alfonsin; mirror dory, *Zenopsis nebulosa*; and horny dogfish, *Squalus blainvillei*. The duration of the trawl hauls at NW Hancock ranged from 5 to 23 minutes/haul and averaged 14.1 minutes for a total of 2.8 hours of trawling (Table 6). The 12 hauls produced 1,742 kg of pelagic armorhead and 89 kg of alfonsin, or a ratio of 19:1. The CPUE varied from <1 to 4,587 kg/hour and averaged 748 kg/hour. Of the 12 hauls made at NW Hancock, only one produced a fairly large catch (1,309 kg) of pelagic armorhead. The remaining hauls produced 208 kg or less. The percentage of pelagic armorhead in the catch varied widely from 15 to 95 percent and averaged 83 percent.

The average catch rate at SE Hancock was higher than that at NW Hancock; however, monitoring of both seamounts will be required before definitive conclusions can be drawn about the stock. Trawling time per haul at SE Hancock ranged from 19 to 38 minutes, averaged 23.7 minutes/haul, and totaled 2.8 hours over seven trawl stations. The total catch included 3,534 kg of pelagic armorhead and 58 kg of alfonsin, or a ratio of 49:1. The CPUE varied from <1 to 4,595 kg/hour and averaged 1,348 kg/hour. Pelagic armorhead constituted between 30 and 99 percent of the catch.

At Seamount 10, the catch was practically nil in a 12-minute haul. A single haul at Seamount 11 with the Norwegian trawl produced only small numbers of red bigeye, *Cookeolus boops*, and grouper, *Caprodon schlegelii*. Both seamounts, however, require considerable additional sampling before reliable estimates can be made of the resources.

Handlining

Results from handline fishing indicated that the trawl catches were not representative of the seamount community. Handline fishing stations were occupied nine times each at NW and SE Hancock Seamounts, four times at Seamount 11, seven times at Ladd Seamount, and twice each at Nero Seamount, Seamount 9, and Seamount 8; the catches included 25 fish species representing 15 families (Table 7, 8). Of the 15 families sampled, 10 were also rep-

Table 7.—Fishes caught on the *Townsend Cromwell* by handlining on Hancock and other seamounts. The species are listed in descending order of their abundance (total catch) in weight.

Scientific name	Family	No.	Weight (kg)
Etelis carbunculus	Lutjanidae	170	363.06
Epinephelus quernus	Serranidae	36	359.64
Pentaceros richardsoni	Pentacerotidae	343	149.78
Hyperoglyphe japonica	Nomeidae	23	66.45
Scomber japonicus	Scombridae	46	65.93
Seriola dumerili	Carangidae	7	64.82
Squalus blainvillei	Squalidae	53	62.85
Caranx ignobilis	Carangidae	1	28.70
Cookeolus boops	Priacanthidae	9	19.40
Etelis coruscans	Lutjanidae	2	16.69
Pristipomoides zonatus	Lutjanidae	11	16.52
Decapterus tabl	Carangidae	12	13.28
Promethichthys prometheus	Gempylidae	13	12.04
Pontinus macrocephalus	Scorpaenidae	9	11.11
Beryx splendens	Berycidae	13	11.09
Pristipomoides sieboldii	Lutjanidae	8	6.95
Pseudocaranx dentex	Carangidae	1	5.20
Seriola aureovittata	Carangidae	1	5.00
Bodianus oxycephalus	Labridae	2	2.50
Decapterus sp.	Carangidae	1	1.25
Polymixia japonica	Polymixiidae	2	0.80
	Emmelichthyidae	1	0.73
Plectranthias kelloggi	Serranidae	2	0.60
Anthias bicolor	Serranidae	1	0.20
Sphoeroides cutaneous	Tetraodontidae	1	

resented in the trawl catches. In terms of species, however, only eight were also sampled by the trawl. Most of the remaining 17 species (including one unidentified species) were from the families Carangidae and Lutjanidae; members of the families Scombridae, Scorpaenidae, Labridae, and Tetraodontidae contributed most of the remainder.

Although handline fishing is selective in that the bait used, depth fished, hook size, and bottom type influence the species composition of the catch, the catch results were particularly valuable in providing information on fish distribution. Going from northwest to southeast, we found the Hancock Seamounts' handline catches dominated by pelagic armorhead; alfonsin; butterfish, *Hyperoglyphe japonica*; chub mackerel, *Scomber japonicus*; mackerel scad, *Decapterus tabl*; two groupers, *Plectranthias kelloggi* and *Anthias bicolor*; and horny dogfish. At Seamount 11, catches of horny dogfish predominated; however, members of the tropical snapper-grouper complex were also more in evidence (Table 8). At Ladd and Nero Seamounts, members of the pelagic armorhead-alfonsin complex were almost completely absent, whereas fishes of the snapper-grouper complex such as red snapper, *Etelis carbunculus* (formerly *E. marshi*); grouper, *Epinephelus quernus*; amberjack, *Seriola dumerili*; Brigham's snapper, *Pristipomoides zonatus*; and pink snapper, *P. sieboldii*; were prominent in the catches.

Our results corroborated those of Japanese investigators who found that the pelagic armorhead-alfonsin complex over the summits of the central North Pacific seamounts gave way to a fish community dominated by tropical species in areas with warmer waters and over those seamounts to the east of the 180th meridian (Japan Marine Fishery Resource Research Center, 1973; Japan Fisheries Agency, 1974; Sasaki, 1974, 1978).

Table 8.—Number of fish caught by handline at the various seamounts and arranged by families in their phyletic order (weight in kilograms in parentheses).

Family and species	NW Hancock	SE Hancock	Seamount 11	Ladd	Nero	Seamount 9	Seamount 8
Squalidae							
Squalus blainvillei	8 (14.17)	34 (42.96)	10 (1.56)	1 (4.16)	—	—	—
Polymixiidae							
Polymixia japonica	—	—	—	<1	2 (0.80)	—	—
Berycidae							
Beryx splendens	11 (9.55)	2 (1.54)	—	<1	—	—	—
Scorpaenidae							
Pontinus macrocephalus	—	—	—	5 (6.22)	3 (3.50)	1 (1.39)	—
Serranidae							
Epinephelus quernus	—	—	4 (36.92)	8 (92.32)	10 (73.50)	6 (72.51)	8 (84.39)
Anthias bicolor	1 (0.20)	—	—	<1	—	—	—
Plectranthias kelloggi	1 (0.40)	1 (0.20)	—	<1	—	—	—
Priacanthidae							
Cookeolus boops	—	—	4 (6.80)	2 (5.20)	3 (7.40)	—	—
Carangidae							
Pseudocaranx dentex	—	—	—	<1	1 (5.20)	—	—
Caranx ignobilis	—	—	—	—	—	—	1 (28.70)
Decapterus sp.	—	—	—	1 (1.25)	—	—	—
D. tabl	1 (1.25)	11 (12.03)	—	<1	—	—	—
Seriola aureovittata	—	—	—	1 (5.00)	—	—	—
S. dumerili	—	—	—	<1	—	1 (9.57)	6 (55.25)
Lutjanidae							
Etelis carbunculus	—	—	—	55 (126.39)	77 (153.90)	7 (10.11)	31 (72.66)
E. coruscans	—	—	—	2 (16.69)	—	—	—
Pristipomoides sieboldii	—	—	—	5 (5.31)	1 (0.70)	2 (0.94)	—
P. zonatus	—	—	—	<1	—	1 (2.08)	10 (14.44)
Emmelichthyidae	—	—	—	<1	—	1 (0.73)	—
Pentacerotidae							
Pentaceros richardsoni	188 (85.67)	154 (62.11)	—	1 (2.00)	—	—	—
Labridae							
Bodianus oxycephalus	—	—	—	<1	2 (2.50)	—	—
Gempylidae							
Promethichthys prometheus	—	—	—	12 (11.24)	1 (0.80)	—	—
Scombridae							
Scomber japonicus	2 (2.56)	44 (63.37)	—	<1	—	—	—
Nomeidae							
Hyperoglyphe japonica	15 (29.75)	7 (27.70)	—	1 (9.00)	—	—	—
Tetraodontidae							
Sphoeroides cutaneous	—	—	—	1 (<1)	—	—	—

Table 9.—Fishes and invertebrates caught on the *Townsend Cromwell* by trap on Hancock and other seamounts. The species are listed in descending order of their abundance (total catch) in weight.

Scientific name	Family	No.	Weight (kg)
Squalus blainvillei	Squalidae	134	148.41
Epinephelus quernus	Serranidae	15	91.64
Seriola dumerili	Carangidae	3	27.00
Pristipomoides filamentosus	Lutjanidae	5	19.91
Pseudocaranx dentex	Carangidae	3	12.49
Polypus sp.	Polypodidae	4	10.27
Gymnothorax steindachneri	Muraenidae	9	7.50
Etelis carbunculus	Lutjanidae	2	5.22
Physiculus grinnelli	Moridae	19	5.03
Gymnothorax sp.	Muraenidae	3	4.19
	Congridae	2	3.73
Ariosoma bowersi	Congridae	1	2.40
Scyllarides squammosus	Scyllaridae	1	1.38
	Moridae	7	1.34
Conger wilsoni	Congridae	1	1.27
	Muraenidae	1	1.15
Pentaceros richardsoni	Pentaceros-tidae	2	1.01
Plectranthias kelloggi	Serranidae	4	0.80
Gymnothorax berndti	Muraenidae	1	0.77
Congrellus aequoreus	Congridae	2	0.68
Coris ballieui	Labridae	5	0.58
Antigonia steindachneri	Antigoniidae	2	0.20
Etmopterus villosus	Squalidae	1	0.10
Antigonia eos	Antigoniidae	2	0.06
Parapercis multifasciata	Parapercidae	1	—
Squalus sp.	Squalidae	1	—
Gymnothorax undulatus	Muraenidae	1	—
	Bramidae	2	—
Chaetodon miliaris	Chaetodon-tidae	2	—
Chaetodon fremblii	Chaetodon-tidae	1	—
Lupocyclus quinquedentatus	Portunidae	1	—
	Astropectin-idae	16	—
	Paguridae	81	—
	Echinome-tridae	8	—
Calappa sp.	Calappidae	2	—
	Gastropoda	2	—

Table 10.—Number of fish caught by fish and lobster traps at various seamounts and arranged by families in phyletic order (weight in kilograms in parentheses, when available).

Family and species	NW Hancock	SE Hancock	Seamount 11	Nero	Ladd	Seamount 8
Astropectinidae			1	5	10	—
Echinometridae			—	8	—	—
Gastropoda (Class)	—	—	—	—	2	—
Polypodidae						
Polypus sp.	—	—	—	—	[1]— (10.27)	—
Scyllaridae						
Scyllarides squammosus	—	—	—	—	—	1 (1.38)
Paguridae						
Dardanus spp.	—	—	—	31	38	12
Calappidae						
Calappa sp.	—	—	—	—	—	2
Portunidae						
Lupocyclus quinquedentatus	—	—	—	—	1	—
Squalidae						
Etmopterus villosus	—	1 (0.10)	—	—	—	—
Squalus sp.	—	1	—	—	—	—
Squalus blainvillei	7 ([2]8.26)	120 (121.63)	6 (13.27)	1 (5.25)	—	—
Muraenidae						
Gymnothorax sp.	—	—	3 (4.19)	—	—	—
G. berndti	—	—	—	—	1 (0.77)	—
G. steindachneri	—	—	—	2 ([3]1.88)	7 (5.62)	—
G. undulatus	—	—	—	1	—	—
Moray (unidentified)	—	—	—	—	1 (1.15)	—
Congridae						
Ariosoma bowersi	—	—	—	—	1 (2.40)	—
Conger wilsoni	—	—	1 (1.27)	—	—	—
Congrellus aequoreus	—	—	—	—	2 (0.68)	—
Conger eels (unidentified)	—	—	—	—	2 (3.73)	—
Moridae						
Physiculus grinnelli	—	—	—	6 (1.70)	13 (3.33)	—
Morid fishes	—	1 (0.17)	6 (1.17)	—	—	—
Antigoniidae						
Antigonia eos	1 ([2]0.03)	1 (0.03)	—	—	—	—
A. steindachneri	2 ([3]0.20)	—	—	—	—	—
Serranidae						
Epinephelus quernus	—	—	7 (33.04)	—	8 (58.60)	—
Plectranthias kelloggi	4 ([2]0.80)	—	—	—	—	—
Carangidae						
Pseudocaranx dentex	—	—	—	—	3 (12.49)	—
Seriola dumerili	—	—	—	3 (27.00)	—	—
Lutjanidae						
Etelis carbunculus	—	—	—	—	2 (5.22)	—
Pristipomoides filamentosus	—	—	—	2 (12.01)	—	3 (7.90)
Bramidae	—	—	—	—	2	—
Chaetodontidae						
Chaetodon fremblii	—	—	—	—	—	1
C. miliaris	—	—	—	—	1	1
Pentacerotidae						
Pentaceros richardsoni	—	2 (1.01)	—	—	—	—
Labridae						
Coris ballieui	—	—	—	—	4 (0.46)	1 ([3]0.12)
Parapercidae						
Parapercis multifasciata	1	—	—	—	—	—

[1]Number caught not recorded; estimated to be fewer than seven animals.
[2]Estimated from average weight of handline and trawl-caught specimens.
[3]Estimated from average weight of trap-caught specimens.

Trapping

The fishes and invertebrates caught in the fish traps and lobster pots on the six cruises are presented in Table 9. Of primary interest is that only two pelagic armorhead and no alfonsin were caught in 60 trap-nights and 176 pot-nights of effort expended. It was suggested that pelagic armorhead and alfonsin do not feed in the area immediately adjacent to the summits and, therefore, are not vulnerable to traps. Examination of our handline catches, however, showed that they were usually taken on hooks fishing closest to the bottom. This indicated that although these species feed near the bottom, they cannot be trapped readily.

Representatives of 13 fish families including 24 species were caught in the traps (Table 10); the horny dogfish was the dominant species in the catches. Of the 13 families, 9 were also represented in the trawl catch; however, 15 of the positively identified species were not present in the trawl catch. With the exception of pelagic armorhead and alfonsin, the handline catches differed from the trawl catches in that most of the other species in the handline catches included members of the snapper-grouper complex. The trap and pot catches, on the other hand, included large numbers of not only horny dogfish, snappers, groupers, and carangids, but also bottom-dwelling forms such as conger eels, including *Ariosoma bowersi*, *Conger wilksoni*, *Congrellus aequoreus*, and an unidentified species; and moray eels, including *Gymnothoras berndti*, *G. steindachneri*, *G. undulatus*, *Gymnothorax* sp., and an unidentified species; and invertebrates such as starfish, Astropectinidae; and hermit crabs, *Dardanus* spp. Other invertebrates caught in the traps and pots

Figure 9.—Pelagic armorhead, *Pentaceros richardsoni*. Examples of "fat" (upper right), "intermediate" (center), and "lean" (lower right) fish, which are discussed in the section "Pelagic Armorhead."

included octopus, *Octopus* sp.; slipper lobster, *Scyllarides squammosus*; swimming crab, *Lypocyclus quinquedentatus*; box crab, *Calappa* sp.; sea urchin, Echinometridae; and unidentified gastropods.

Target Species' Biology

Pelagic Armorhead

Formerly considered a rare species because of the paucity of reports on its capture, the pelagic armorhead (Fig. 9), in the family Pentacerotidae, is broadly distributed in the North Pacific between lat. 30° and 50°N (Takahashi and Sasaki, 1977). The outstanding feature of members of this family is the unusual armature of the head, which is almost completely enclosed in exposed, rough, striated bones (Smith, 1964).

Very little is known about the life history of this species. Eggs and larvae are thought to be free-floating and dispersed by waters of the North Equatorial Current (Chikuni, 1971b). It has also been hypothesized that the juveniles remain pelagic until age 4-5 (25-30 cm fork length) when they begin a demersal existence over the seamounts.

In addition to the Pacific seamounts we have discussed, pelagic armorhead have been recorded from New Zealand, Australia, the northern part of the Hawaiian Archipelago, Japan, Gulf of Alaska, British Columbia, Oregon, and California (Abe, 1957; Clemens and Wilby, 1961; Wagner and Bond, 1961; Follett and Dempster, 1963; Honma and Mizusawa, 1969).

Not all seamounts in the North Pacific have populations of pelagic armorhead. Trawling surveys over Patton (lat. 54°40′N, long. 150°30′W) and Cobb Seamounts (lat. 46°46′N, long. 130°49′W) in the northeastern Pacific have not demonstrated the presence of pelagic armorhead (Chikuni, 1971a, b). Seamounts north of lat. 35°N in the Emperor Chain have summits so deep that the possibility of finding pelagic armorhead on them appears rather remote. Furthermore, those seamounts located on the Hawaiian Ridge to the east of the 180th meridian are relatively shallow and trawling surveys have demonstrated that their fauna is subtropical and do not include the pelagic armorhead (Sasaki, 1978).

Pelagic armorhead also make extensive vertical migrations, depending on the location in the North Pacific. Japanese trawlers have fished for pelagic armorhead in depths varying from 300 to 600 m over the central North Pacific seamounts. However, unlike other mesopelagic species that ascend into the surface layers at night and descend to great depths during the day, pelagic armorhead have been found close to the top of the seamounts at night in most instances. Furthermore, reports of their capture by handlines suggested that the pelagic armorhead may also be schooling at the surface at night (Chikuni, 1970).

Other reports suggest that pelagic armorhead do not confine their vertical migration to the water mass overlying the tops of the seamounts. Observations by Kitani and Iguchi (1974) showed that they rise above and descend below the top of the seamount during the day and night, respectively. The catch per unit of effort by trawling usually peaked between 0300 and 0700 hours and between 1700 and 1900 hours. Therefore, the pelagic armorhead appear to migrate through the level of the seamount summit twice a day—once in the morning and again in the evening.

Studies on feeding behavior support the contention that pelagic armorhead feed at night near the surface. Observations on aquarium-held fish indicate that pelagic armorhead in their natural environment probably feed at night on organisms occurring near the surface (Hart, 1973). Stomach contents of pelagic armorhead caught over the seamounts contained euphausids, mysids, copepods, salps, shrimps, myctophids, and other organisms usually associated with the deep-scattering layer (Sasaki, 1973, 1974). Since the deep-scattering layer ascends toward the surface at night and remains deeper during daylight, the results of the stomach analysis tend to agree with aquarium observations.

The fork lengths of unsexed pelagic armorhead caught by trawling showed strong unimodal distributions. At NW Hancock, the fish ranged from 23.3 to 39.8 cm (average 29.7 cm) and 67 percent were between 29 and 31 cm (Fig. 10). The fish from SE Hancock showed a similar narrow length range of 23.3-35.9 cm and averaged 29.9 cm, which was nearly identical to that found for NE Hancock (Fig. 11). Here about 62 percent of the fish fell within the 29-31 cm

length range. An analysis of variance showed that mean size at NW Hancock was not significantly different from that at SE Hancock ($F = 1.65$; df = 1 and 553; $P > 0.05$). Males, however, differed significantly in size from females (Table 11). The average size of females was from 0.8 to 1.4 cm larger than that of the males.

One of the more perplexing problems in the life history of the pelagic armorhead is the morphological differences of fish over the various seamounts in the Pacific. Sasaki (1974) reported that the northeastern Pacific stock has a higher proportion of the "fat" type, whereas the central North Pacific stock has more "lean" fish. Coloration also differs. The "fat" type has a dark blue dorsal and white ventral regions which are typical of surface-dwelling fish. Some are also reticulated. The "lean" fish over the central North Pacific seamounts have been reported to be uniformly gray and without any markings.

On cruises of the *Townsend Cromwell* prior to 1980, as much as 95 percent of the pelagic armorhead caught at Hancock Seamounts were "lean." In 1980, however, about 20 percent of the fish at NW Hancock and about 15 percent at SE Hancock were "fat." By 1981 we found that proportion of "fat" to "lean" completely reversed from former years. From one trawl haul at SE Hancock, the catch included 94 percent "fat" and only 6 percent "lean." Furthermore, many of the "fat" fish could be classified into a third "intermediate" category and there actually was a gradation of body types from "very fat" to "very lean" (Fig. 9). This gradation of body types can also be seen in data collected by U.S. observers on the Japanese trawlers in 1980-81 (Table 12).

One explanation offered for the occurrence of "fat" and "lean" fish is that the body types are related to reproductive condition because a large number of the gonads of both sexes of "lean" fish were in the spent stage (Takahashi and Sasaki, 1977). This points to a possibility that the "lean" fish were unable to recover from the spawning ordeal. The "lean" fish, in many cases, showed signs of deterioration (i.e., the skin peeled off their bodies very readily (Kuroiwa, 1973)).

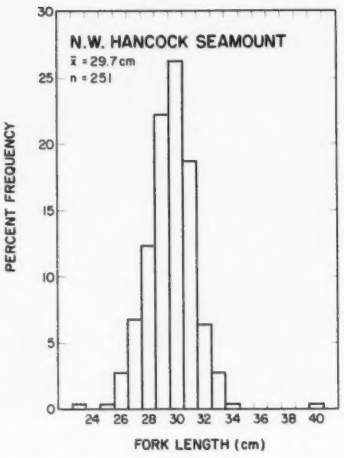


Figure 10.—Length-frequency distribution of pelagic armorhead caught at NW Hancock Seamount during *Townsend Cromwell* cruise 80-02.

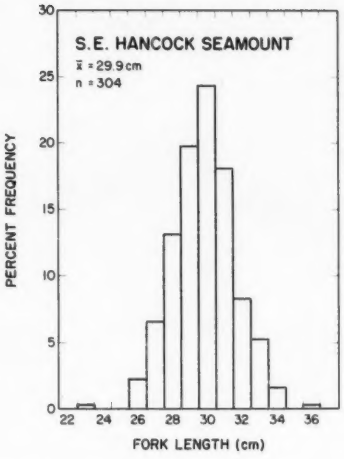


Figure 11.—Length-frequency distribution of pelagic armorhead caught at SE Hancock Seamount during *Townsend Cromwell* cruise 80-02.

Table 11.—Analysis of variance on the mean length of pelagic armorhead measured by sex, at NW and SE Hancock Seamounts.

		No. measured		Mean length (cm)			
Seamount	Cruise	Male	Female	Male	Female	Values of F	Probability
NW Hancock	78-03	23	46	29.6	30.7	7.70	0.01
	80-02	77	45	28.7	30.1	27.73	0.01
SE Hancock	78-01	19	53	29.0	30.1	17.19	0.01
	81-02	49	26	28.9	29.7	9.36	0.01

Table 12.—The percentage of "fat," "lean," and "intermediate" body types of pelagic armorhead in the catch of Japanese trawlers fishing at Hancock Seamounts in 1978-81.

			Percentage		
Vessel name	Date	Seamount	"Fat"	"Lean"	"Intermediate"
Ryuyo Maru No. 2	4/22- 6/ 3/78	Hancock	2	98	
Aso Maru	5/27- 7/10/79	Hancock	5	95	
Kitakami Maru	8/ 9-10/ 4/80	NW Hancock	27	73	
		SE Hancock	43	57	
Aso Maru	9/24- 9/30/80	NW Hancock	11	45	43
		SE Hancock	13	35	52
Aso Maru	6/ 9- 6/19/81	NW Hancock	60	25	15
		SE Hancock	59	24	17
Kitakami Maru	8/15-10/ 1/81	NW Hancock	67	33	
		SE Hancock	61	39	

Studies conducted by the Soviets and Japanese have demonstrated that spawning of pelagic armorhead begins in November-December, peaks in January-February, and declines in March (Iguchi, 1973; Sasaki, 1974; Takahashi and Sasaki, 1977). Therefore, one would expect the proportion of "lean" fish in the catch to be high during the post-spawning period. Data from our research cruises indicate otherwise. For

example, from one trawl haul by the *Townsend Cromwell* at SE Hancock in March 1981, the catch was composed of 94 percent "fat" and 6 percent "lean" fish. If spawning peaked in January-February, then there should be a large proportion of "lean" fish in the catch in March. In addition, data from a Japanese trawler fishing from April through June 1978 indicated that "lean" fish represented 98 percent of the catch from Hancock, whereas on another trip from May through July 1979, 95 percent of the catch was "lean" (Table 12). It also appears that "fat" and "lean" fish are not segregated by depth because both body types are found in the same trawl haul. The inconsistency in these results points out the complexity of the pelagic armorhead's life history pattern and that additional studies are necessary to understand the changes in their morphological characteristics.

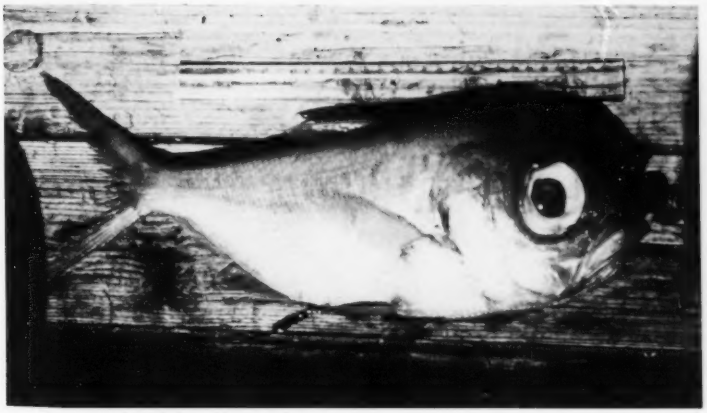


Figure 12.—Alfonsin, *Beryx splendens*.

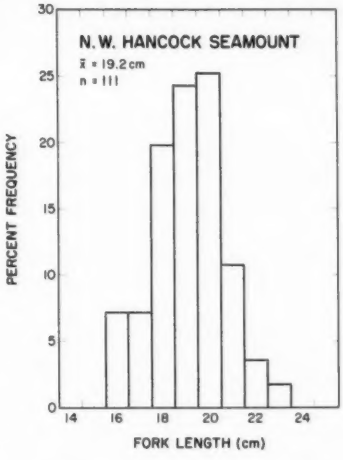


Figure 13.—Length-frequency distribution of alfonsin caught at NW Hancock Seamount on *Townsend Cromwell* cruise 80-02.

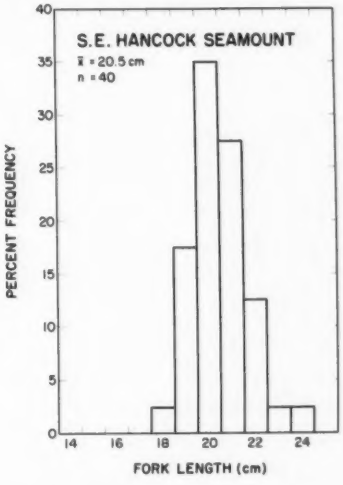


Figure 14.—Length-frequency distribution of alfonsin caught at SE Hancock Seamount on *Townsend Cromwell* cruise 80-02.

Alfonsin

The alfonsin (Fig. 12) which belongs to the Berycidae, a high-seas family of fishes, is bright red and inhabits rocky bottom several hundred meters deep. The species is found mainly in the western North Pacific where for many years it has been caught by handlines in Sagami Bay and Kashima Nada in the inshore areas of Japan and on the banks and slopes around Izu (South Honshu Ridge). In 1970, alfonsin were reported from Kinancho on the Kinan Seamount Range and the Kyushu-Palau Seamount Range. They also occur over the Emperor Seamounts where they were first taken by Soviet trawlers in November 1967 (Sakiura, 1972), and were caught by hook and line beginning in 1973 (Masuzawa et al., 1975). In the trawl fishery, alfonsin constitute only a small percentage of the catch.

A closely related species, *Beryx decadactylus*, has been taken in small numbers together with alfonsin. *Beryx decadactylus* has also been taken near Saipan in the Commonwealth of the Northern Mariana Islands with bottom gill nets.

Near Japan, alfonsin spawn between August and October and the eggs are transported by the Kuroshio (Chikuni, 1971b). Artificial propagation experiments showed that the berycoid eggs float and hatch in about 2 days at 23°C and newly hatched larvae float for 2-3 days before they begin to swim on the fourth day (Onishi, 1967). Therefore, the distribution of the larvae is wholly dependent on the Kuroshio and its offshoots.

Alfonsin migrate vertically during the evening to feed near the surface. Analysis of stomach contents of fish caught over the Emperor Seamount Chain disclosed that small fish predominated in 43 percent of the stomachs, whereas crustaceans (decapods, mysids, and euphausids) predominated in 37 percent of the samples. No information was available on the remaining 20 percent of the fish sampled (Aomori Prefectural Fisheries Experimental Station, 1976).

Figures 13 and 14 show the length-frequency distributions of unsexed al-

fonsin caught by trawl at NW and SE Hancock. Those caught at NW Hancock ranged from 15.7 to 23.0 cm and averaged 19.2 cm whereas those caught at SE Hancock had a narrower size range, from 18.2 to 23.7 cm, and averaged 20.5 cm. There was a highly significant difference in sizes of fish from the two seamounts ($F = 25.69$; df = 1 and 149; $P < 0.01$).

Summary and Conclusions

The seamount-groundfish trawl fishery expanded rapidly after 1967 when exploratory fishing by Soviet trawlers demonstrated the presence of commercial concentrations of pelagic armorhead and smaller quantities of alfonsin. In 1969, Japanese trawlers entered the fishery and their catches fluctuated widely until 1972, thereafter stabilizing at 18,952-34,538 t. Although the catch peaked in 1974, CPUE peaked much earlier, reaching 60.2/hour in 1972, then declined steadily to 9.7/hour by 1976. Unpublished Japanese data indicate that CPUE continued its downward trend in 1977-81, fluctuating between 0.3 and 2.4 t/hour.

During 1972-76, Hancock Seamounts, which fall within the U.S. FCZ around the Hawaiian Archipelago, received from 1 to 29 percent of the entire central North Pacific trawling effort by the Japanese. The catches during this period fluctuated from 653 to 8,518 t or roughly from 3 to 34 percent of the central North Pacific pelagic armorhead catch.

Based on catch data, the center of abundance of pelagic armorhead is near Colahan, C-H, and Hancock Seamounts, whereas that for alfonsin is in more northerly latitudes near Kimmei Seamount in the Emperor Seamount Chain.

In 1978-81, U.S. observers collected data on three Japanese trawlers that made six trips to Hancock Seamounts. These data indicated that after the intense fishing pressure applied prior to 1977, it had begun to improve and showed an upward trend although the CPUE was still considerably below the pre-1977 level.

Life history aspects of the pelagic armorhead are not well understood at present; however, much of the alfonsin's biology and ecology have been investigated by the Japanese.

Data collected by the *Townsend Cromwell* during research cruises to the seamounts in the Hawaiian Archipelago demonstrated that the species complex changes abruptly near Midway Islands. The pelagic armorhead-alfonsin complex predominated at Hancock Seamounts near the northern edge of the U.S. FCZ; however, slightly south of Hancock near Midway Islands and Kure Atoll, the snapper-grouper complex predominated at Ladd, Nero, and other unnamed seamounts in that area.

There was no significant difference in the mean length of pelagic armorhead from NW and SE Hancock. However, females were consistently larger than males. Significant differences in mean sizes were evident in alfonsin caught at NW and SE Hancock. One of the peculiarities noted among the pelagic armorhead population at Hancock Seamounts was the occurrence of "lean" and "fat" fish in the catch. Japanese investigators have hypothesized that body types are related to spawning with "lean" fish, the result of a postspawning condition. Research cruise data collected by the Honolulu Laboratory failed to substantiate this hypothesis. The manner in which apparent abundance (CPUE) of pelagic armorhead declined from its peak in 1972 while effort rose steadily from 1972 to 1976 and remained at relatively high levels in 1977-81 indicates that the trawl fishery has had a real effect on the stock. The failure of total catch to increase with increasing effort suggests that the rate of fishing has been sufficiently intense and may have surpassed the level corresponding to optimum fishing effort.

Although preliminary assessment studies have been attempted, reliable estimates are not possible until several critical problems are addressed. For example, there is a complete lack of catch and effort data from Soviet trawlers, no evidence that the stock and fishery dynamics over one seamount are independent of events occurring over other central Pacific seamounts, no information on what governs recruitment to the seamount habitat, and no logical explanation for the existence of "fat" and "lean" types on the same seamount. To solve these problems, we must promote not only careful assessment of the pelagic armorhead stock over its entire range, but also international management action, should it become necessary.

Acknowledgments

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Trapping Surveys for the Deepwater Caridean Shrimps, *Heterocarpus laevigatus* and *H. ensifer*, in the Northwestern Hawaiian Islands

REGINALD M. GOODING

ABSTRACT—Baited traps were used to assess the geographic and depth distribution of the deepwater caridean shrimps Heterocarpus laevigatus *and* H. ensifer *in the Northwestern Hawaiian Islands. Traps were set in depths ranging from about 290 to 880 m. Both species occurred throughout the length of the chain. Catch rates varied markedly with depth. Highest catches of* H. laevigatus *were made in 500-800 m with a mean catch rate of 0.91 kg per trap-night. For* H. ensifer, *optimum trapping depths were 350-600 m with a mean catch rate of 1.66 kg per trap-night.*

Introduction

The caridean shrimps, *Heterocarpus laevigatus* Bate and *H. ensifer* Milne Edwards (Fig. 1), are deepwater species with a mid-latitude circumglobal distribution extending throughout the eastern and western Atlantic, Indo-west Pacific, Hawaii, and Indian Ocean (Holthuis, 1980). *Heterocarpus laevigatus* inhabits a deeper depth range than *H. ensifer* and, because of its larger size, is generally considered to have the greater commercial potential.

Experimental trapping surveys have shown that both species are widely distributed throughout the central and western Pacific. Exploratory trap fishing has been conducted in Hawaii (Clarke, 1972; Struhsaker and Aasted, 1974); Guam (Wilder, 1977; Moffitt, 1983); New Caledonia (Intès, 1978); Fiji (Brown and King, 1979); Western Samoa (King, 1980a); Vanuatu (King, 1980b, 1981c); Tonga (King, 1981a); and Papua New Guinea (King, 1982).

The available literature indicates that in the Pacific outside of Hawaii *Heterocarpus* is commercially exploited only in a trawl fishery for *H. reedi* off

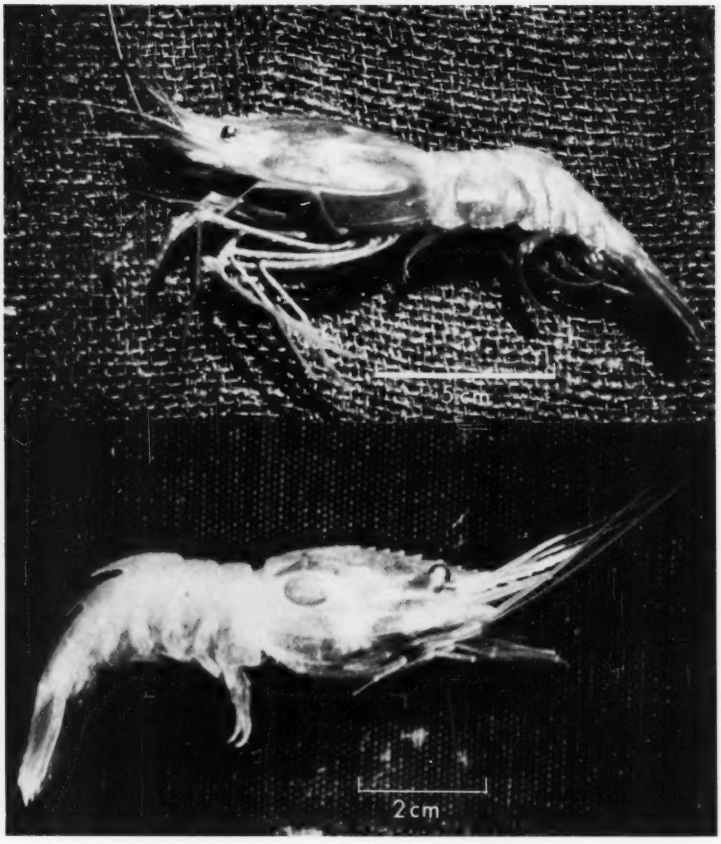

Figure 1.—*Heterocarpus ensifer* (top) and *H. laevigatus*.

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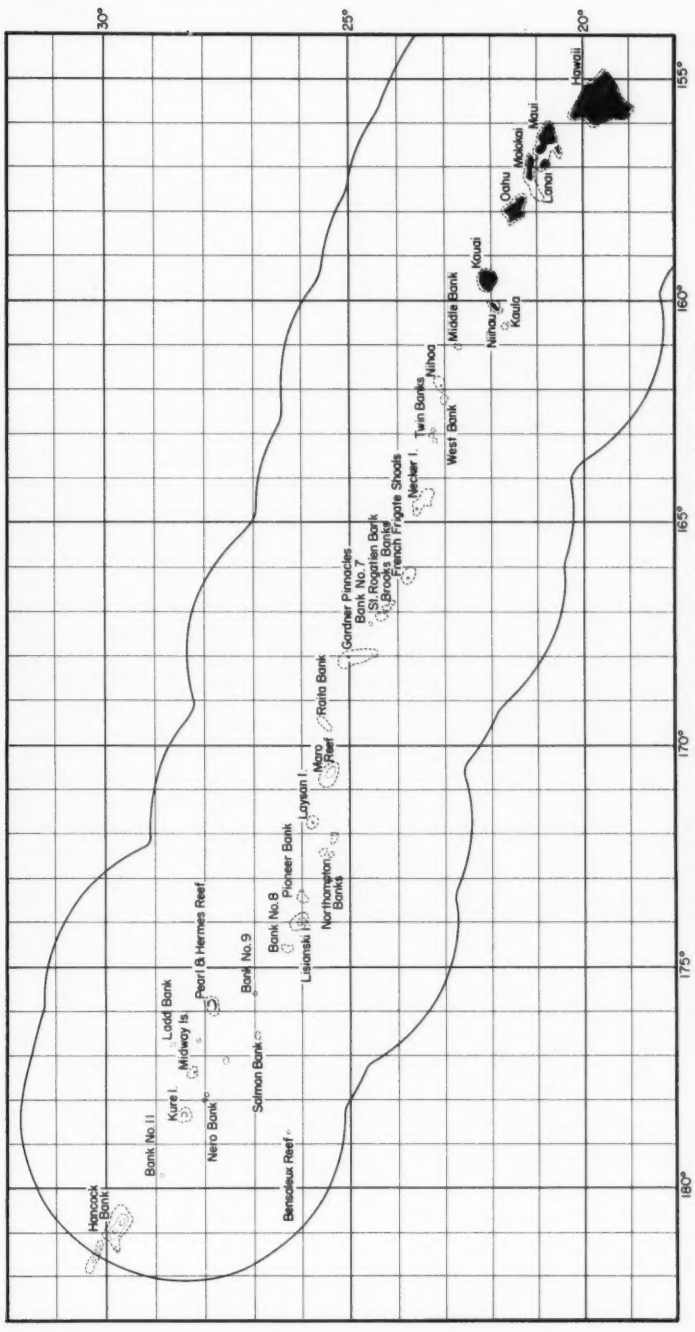

Figure 2. — The Hawaiian Archipelago including the Northwestern Hawaiian Islands.

Chile and Peru (Hancock and Henriquez, 1968; Longhurst, 1970) and in a fishery for *H. vicarius* off Costa Rica and Panama (Holthuis, 1980). Two commercial-scale projects have been conducted to determine the economic feasibility of a fishery for *H. laevigatus* and *H. ensifer* in the Hawaiian Islands (Oishi, 1983; Hawaiian Divers, Inc.[1]). At present, private interests are endeavoring to develop a fishery for deepwater shrimp in the Hawaiian Islands (Schlais, 1983).

During exploratory trawling surveys for penaeid shrimp, *Penaeus marginatus*, conducted by the Honolulu Laboratory of the National Marine Fisheries Service's (NMFS) Southwest Fisheries Center (SWFC), in 1967-68 (Yoshida, 1972), *H. ensifer* and *H. laevigatus* were caught in small numbers (Struhsaker and Yoshida, 1975). Later experimental fishing in Hawaii between 1968 and 1973 (Clarke, 1972; Struhsaker and Aasted, 1974) showed that trapping rather than trawling was a more effective method of fishing for *H. ensifer* and *H. laevigatus*. Those early surveys indicated that the two species might constitute an unexploited resource of considerable commercial potential.

In response to recommendations from the Governor's Task Force on Oceanography of the State of Hawaii (Department of Planning and Economic Development, 1969, 1974), NMFS conducted exploratory deepwater shrimp trapping in various areas in the Hawaiian chain (Struhsaker and Aasted, 1974), including Necker Island, French Frigate Shoals, Laysan Island, and Pioneer Bank in the Northwestern Hawaiian Islands (NWHI) (Fig. 2). From 1975 to 1982, in a cooperative research effort with several other agencies to investigate NWHI marine and terrestrial resources, NMFS made extensive surveys of the offshore finfish and crustacean resources throughout the NWHI

[1]Hawaiian Divers, Inc. 1983. Deepwater shrimp utilization study for Hawaii. Report prepared under NOAA Cooperative Agreement No. 80-ABH-00065 for the Southwest Region, Western Pacific Program Office, Natl. Mar. Fish. Serv., NOAA, P.O. Box 3830, Honolulu, HI 96812. 48 p. (On file at NMFS Southwest Fish. Cent., Honolulu, HI 96812.)

(Uchida et al., 1980). From 1978 to 1981 exploratory trapping for deep-water shrimps was conducted during nine cruises (TC-78-03, TC-79-03, TC-80-02, TC-80-03, TC-80-04, TC-80-05, TC-81-01, TC-81-02, and TC-81-04) of the NOAA ship *Townsend Cromwell*. This report is based on the data collected during that period.

Gear and Methods

The shrimp traps (Fig. 3) were half round, with a frame constructed of 1.27 cm reinforcing steel, covered with 1.27 × 2.54 cm mesh hardware cloth. At each end they had a quadrant-shaped entry of a mean width about 33 cm tapering to an inner opening 8-10 cm in diameter. A bait container (12 × 12 × 27 cm) made of the same mesh hardware cloth was located at the top of each trap near one entrance. On the basis of field tests which showed that covered traps outfished uncovered traps by factors of from 2.5 to 10 (Struhsaker and Aasted, 1974), the tops of the traps were covered with black canvas or burlap. It is generally believed that covered traps may be more effective because the bait scent tends to be concentrated at the trap entrances and cannot easily diffuse through the trap mesh, as it might in uncovered traps. No tests were made during this survey to compare covered and uncovered traps; however, King (1981c) found no significant difference in the mean catch rates of *H. ensifer* between covered and uncovered traps. The number of traps and spacing on the ground line were not consistent throughout the survey. Most sets consisted of either four or five traps spaced 36 m apart. On a few sets, however, six trap strings were fished or traps were spaced at 18 or 45 m. The traps were usually weighted with about 5 kg of chain link, and an anchor was attached to the end trap of each string.

The ground line and buoy line were 1.27 cm polypropylene rope. The buoy line was made up of 92 or 185 m lengths, which were stored in 121 l (32-gallon) plastic garbage containers. This facilitated adjustment of the length of the buoy line appropriate to the depth. To minimize the possibility of marker buoy submergence due to current drag or to trap strings slipping into deeper water, at least a 2:1 and frequently a 3:1 scope ratio was used. The markers consisted of weighted bamboo flagpoles buoyed with either large spherical inflatable or rigid plastic floats. Another plastic float at the end of a short trail line provided reserve buoyancy and facilitated gear retrieval. The bait used throughout the survey period consisted of from two to three (about 1 kg) whole fish, usually either jack mackerel or Pacific mackerel. Trapping stations were occupied from 1600 to 1800 hours in the afternoon until 0800-1000 hours the following morning, allowing an overnight soaking time of 14-18 hours.

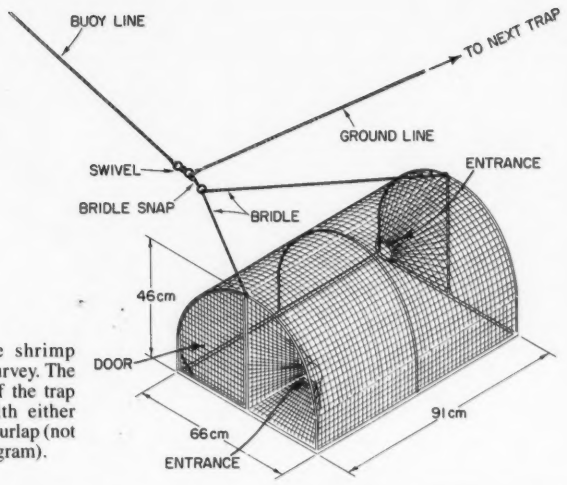

Figure 3.—The shrimp trap used in the survey. The half-round top of the trap was covered with either black canvas or burlap (not shown in the diagram).

The combination of strong currents and precipitous dropoffs along the NWHI banks frequently made it difficult to locate suitable areas for trap stations. To keep gear loss to a minimum, depth sounding transects were always made before setting to determine areas where the slope was not too steep.

Results and Discussion

Fishing Effort and Geographic Distribution

Fifty-four fishing stations consisting of 458 trap-nights of fishing effort were occupied on 17 banks along the entire length of the NWHI. Totals of 199.06 kg of *H. laevigatus* and 479.69 kg of *H. ensifer* were trapped. The fishing effort was not evenly distributed. Some banks such as Necker, French Frigate Shoals, Gardner Pinnacles, and Maro Reef were relatively well surveyed, whereas very little effort was expended on others. Table 1 shows the trapping effort, catch rates, and depth ranges for all banks sampled. Both species were taken at all of the survey areas except Brooks Banks, Raita Bank, Laysan Island, and Lisianski Island, where only *H. ensifer* were caught, and Ladd Bank, where neither species was caught. Some sets at those areas were in depths where *H. laevigatus* usually occurred in other areas sampled. Throughout the survey, however, there was considerable variation in catch rates among traps within a set, and between sets made in the same area at similar depths. Thus, on the basis of the data available, there is little reason not to assume that both species occur at appropriate depths on all the banks in the NWHI chain.

Depth Range

In this report, catch data are related to depth of capture. The distribution of shrimp is possibly related more directly to temperature; however, temperature data were not routinely collected. Depths ranging from 290 to 880 m were sampled; however, depths of <300 m and >800 m received relatively little effort. Figure 4 shows the effort and the catch per unit effort (CPUE) for 50 m depth zones for both species.

Our trapping effort clearly did not sample the shallowest depths at which

Table 1.—Fishing effort, depth range fished, total catches, and catch per unit effort for all areas surveyed in the Northwestern Hawaiian Islands.

Fishing area	Effort (trap-nights)	Depth range fished (m)	*H. laevigatus* Total catch (kg)	*H. laevigatus* Mean catch per trap-night	*H. ensifer* Total catch (kg)	*H. ensifer* Mean catch per trap-night
Southern area						
Nihoa Island	23	368-600	1.38	0.06	25.07	1.09
West Bank	16	338-732	2.16	0.16	7.52	0.47
Twin Banks	6	468	4.44	0.74	20.28	3.38
Necker Island	88	289-867	45.76	0.52	127.60	1.45
French Frigate Shoals	53	368-733	17.49	0.33	129.85	2.45
Brooks Banks	20	329-485	0	0	11.00	0.55
St. Rogatien Bank	31	309-766	7.15	0.23	23.25	0.75
Bank No. 7	12	481-821	8.64	0.72	0.96	0.08
Northern area						
Gardner Pinnacles	70	68-758	83.30	1.19	48.30	0.69
Raita Bank	12	399-427	0	0	15.84	1.32
Maro Reef	74	287-772	25.90	0.35	48.10	0.65
Laysan Island	12	331-879	0	0	1.80	0.15
Northampton Bank	12	540-690	1.20	0.10	3.12	0.26
Lisianski Island	8	459-561	0	0	12.24	1.53
Salmon Bank	12	512-647	0.84	0.07	0.36	0.03
Ladd Bank	4	566	0	0	0	0
Kure Atoll	5	562	0.80	0.16	4.40	0.88

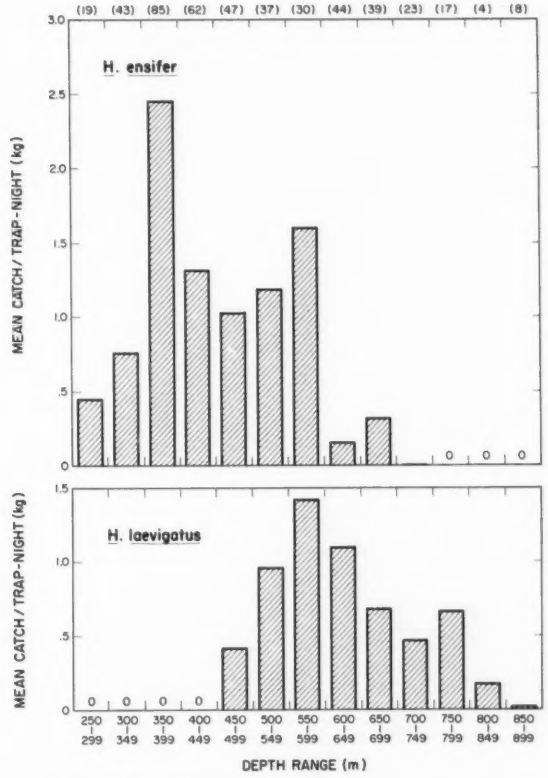

Figure 4.—Catch per trap-night of *Heterocarpus ensifer* and *H. laevigatus* per 50 m depth zone. Effort (trap-nights) is shown in parentheses.

H. ensifer probably occurs in the NWHI. In the main Hawaiian Islands, Clarke (1972) caught *H. ensifer* between 145 and 740 m, and Struhsaker and Aasted (1974) took *H. ensifer* in depths ranging from 137 to 660 m.

Heterocarpus laevigatus were trapped between 453 and 867 m (Fig. 4). Although there were small catches in the 850-899 m depth zone, it appears likely this was close to the maximum depth for this species in the NWHI. Clarke (1972) collected *H. laevigatus* from 365 to 728 m, and Struhsaker and Aasted (1974) caught them in depths from 430 to 825 m. Results obtained by investigators in other areas of the Pacific do not extend maximum depths below those we obtained. King (1981b) reported depth ranges in the southwestern Pacific islands of 285-760 m for *H. ensifer* and 380-860 m for *H. laevigatus*. In his surveys, the range of depth distribution for both species differed to some extent in the various island groups he surveyed. Wilder (1977) found *H. laevigatus* in depths ranging from 457 to 732 m off Guam, but apparently did not sample below the maximum depth he reported for the species.

Of more significance to a fishery are depths of optimum abundance. Figure 4 indicates that the approximate optimum depth range for trapping *H. ensifer* in the NWHI was 350-599 m. Struhsaker and Aasted (1974) found peak abundance of *H. ensifer* in depths of 365-440 m, and Clarke (1972) concluded they were most abundant in depths of 275-455 m. Comparison of the deep end of our optimum depth range with that found by the earlier investigations in the main Hawaiian Islands indicates, as first suggested by Struhsaker and Aasted (1974), that peak abundance of *H. ensifer* may occur deeper in the NWHI than in the main Hawaiian Islands. During exploratory shrimp trapping off the Island of Hawaii by the SWFC Honolulu Laboratory, the optimum depth range for *H. ensifer* was [2]335-618 m, a range very similar to that found during the NWHI survey.

[2]Narrative report, *Townsend Cromwell* cruise 79-05. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

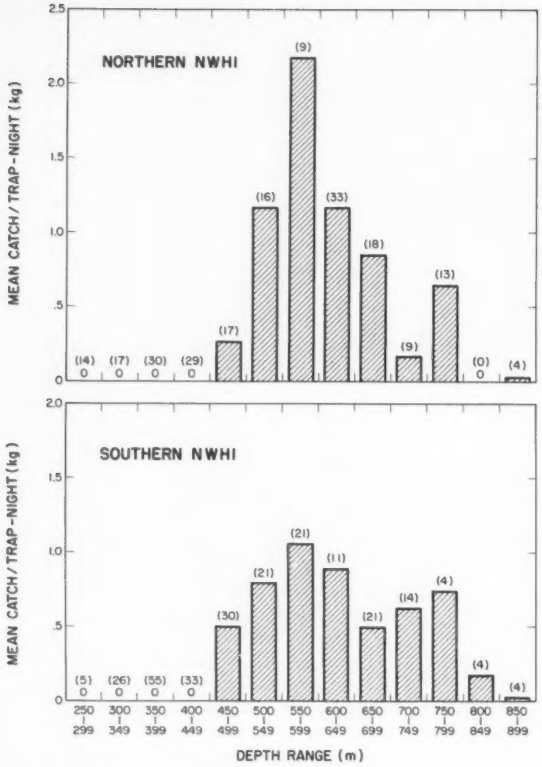

Figure 5.—Catch per trap-night of *Heterocarpus laevigatus* per 50 m depth zone for the northern and southern Northwestern Hawaiian Islands. Effort (trap-nights) is shown in parentheses.

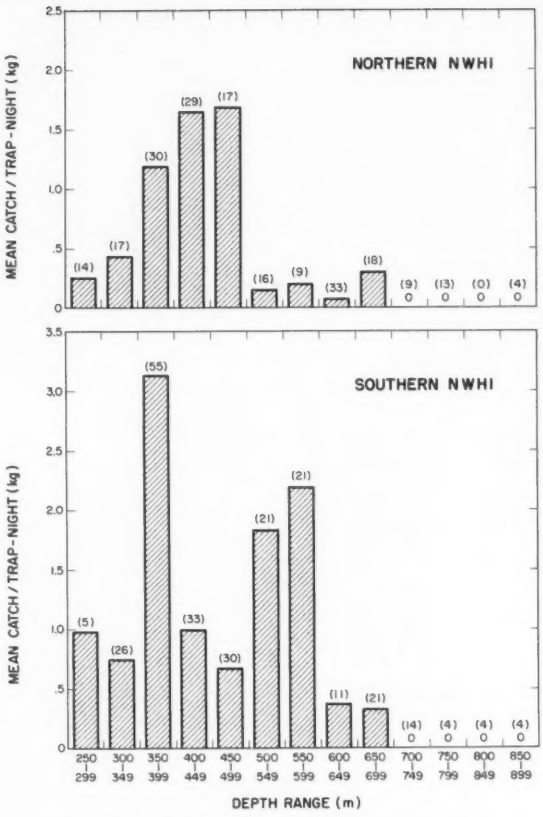

Figure 6.—Catch per trap-night of *Heterocarpus ensifer* per 50 m depth zone for the northern and southern Northwestern Hawaiian Islands. Effort (trap-nights) is shown in parentheses.

The optimum depth range for *H. laevigatus* was 500-799 m (Fig. 4), compared with a range of 440-684 m estimated by Struhsaker and Aasted (1974). The available data seem to indicate that *H. laevigatus* may occur at shallower depths in the main Hawaiian Islands than in the NWHI. During this survey, *H. laevigatus* were not caught in <453 m whereas they have been taken at 365 m (Clarke, 1972), 430 m (Struhsaker and Aasted, 1974), and 391 m (footnote 2). At Kure Atoll, the most northerly area sampled, the CPUE of *H. laevigatus* was low at a trapping depth of 562 m (Table 1) which was in the depth zone of peak catches for the overall NWHI survey. However, no other depths were sampled at Kure Atoll. Commercial fishing interests have also found that both *H. laevigatus* and *H. ensifer* occur deeper in the NWHI than in the main islands[3].

Northern and Southern Areas

The data did not allow an examination of south to north trends within the NWHI. In an attempt to determine if there were any obvious differences in catch rates and depth distribution of the two species between southern and northern sections of the survey area, the catch data were segregated for Nihoa Island to Bank No. 7 (southern area) and Gardner Pinnacles to Kure Atoll (northern area) (Fig. 5, 6). The two areas were chosen on the basis of more or less equally distributed sampling effort. A total of 249 trap-nights were fished in the southern area and 209 trap-nights in the northern area.

There was no indication that within the NWHI the peak abundance of *H.*

[3]M. D. Dailey, Hawaiian Islands Shrimp Co., 737 Bishop Street, Suite 2910, Honolulu, HI 96813. Pers. commun., January 1984.

laevigatus occurred any deeper in the northern part of the survey area. Figure 5 shows that the depth distributions for that species were very similar in the southern and northern sections. The CPUE peaked at the 550-599 m depth zone in both areas; however, catch rates were higher for nearly all the depth zones in the north.

For *H. ensifer* in the northern area (Fig. 6), the highest catch rates were confined to depths ranging from 350 to 499 m, whereas in the south the better catches were spread across a wider range of depths (250 to 599 m). Again, for this species there is no indication that peak abundance occurred any deeper in the north. Indeed, the available data indicate the opposite.

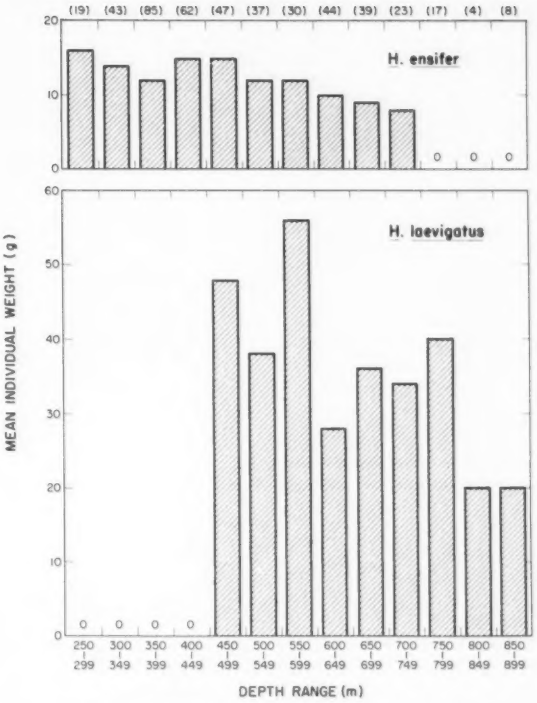

Figure 7.—Mean individual weight of *Heterocarpus ensifer* and *H. laevigatus* per 50 m depth zone. Effort (trap-nights) is shown in parentheses.

Size by Depth

Previous investigators have demonstrated that the maximum mean size of *H. ensifer* occurs within the depth range of peak abundance, and smaller shrimp occur at shallower and deeper depths (Clarke, 1972; Struhsaker and Aasted, 1974; King, 1981c). During the NWHI survey, length data were not routinely collected. However, total number of individuals and total weight of the two species were recorded, allowing calculation of mean individual weight per trap.

For *H. ensifer*, the NWHI data are in partial agreement with those of other surveys. There was a trend toward decreasing size as depth increased from 450 m to the maximum depth (Fig. 7), which paralleled the sharply declining CPUE over the same depth range (Fig. 4). However, at the depth of peak abundance (350-399 m), there was actually a decline in mean individual weight and an increase towards the shallowest depth sampled. It is possible that had shallower depths been sampled, there may have been a decline in shrimp weight towards the shallowest end of the depth range.

As with *H. ensifer*, the NWHI data for *H. laevigatus* indicate a decline in shrimp size only from the depth range of peak abundance towards deeper water. Figures 4 and 7 show that relatively large *H. laevigatus* were caught at the shallowest end of their range, and that the largest weight class occurred at the depth zone of maximum abundance (550-599 m). Net mean individual weight declined with CPUE towards the deep end of the range.

The relationship between CPUE (in terms of weight) and depth was not significantly affected by variations in mean weight of the shrimp. Figure 8 shows numbers of shrimp per trap-night per depth zone. The only marked change in the overall picture when the data are presented this way is that for *H. laevigatus* there was a shift in peak abundance from the 550-599 m to the 600-649 m depth zone, further emphasizing the sharp decline in the weight of *H. laevigatus* between the two zones (Fig. 7).

Catch by Season

Clarke (1972) did not get a clear picture of seasonal change, based on data from single trap sets off Kaneohe, Oahu, at 1-month intervals from January to October. His very limited data indicated that all low catches and no really large ones were made between March and September, suggesting lower abundance during the summer. In Fiji, King (In press) found that catch rates did not change significantly with season.

During the NWHI survey, the trapping effort was not well distributed over all months or even seasons. The midsummer months received a large proportion of the effort whereas the midwinter months received relatively little effort. However, when the data are segregated on a two-season basis, the distribution of effort is reasonably good (273 trap-nights during April-September, and 185 trap-nights during October-March). Figure 9 shows the CPUE and mean

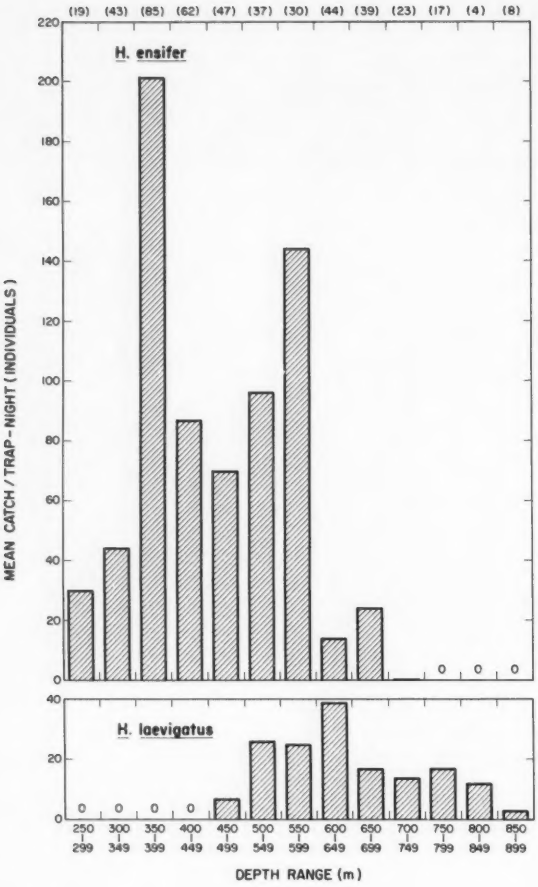

Figure 8.—Mean catch per trap-night (individuals) per 50 m depth zone. Effort (trap-nights) is shown in parentheses.

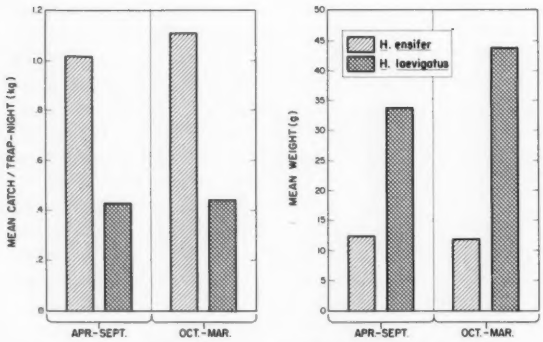

Figure 9.—Mean catch per trap-night and mean individual weight of *Heterocarpus ensifer* and *H. laevigatus* for spring-summer and fall-winter seasons.

weight of catch for spring-summer and fall-winter seasons. The CPUE for both species of *Heterocarpus* was almost identical for both periods. There was no difference in the mean weight of the catch of *H. ensifer* taken in April-September, compared with October-March. The mean weight of *H. laevigatus* was larger in the October-March catches than in the April-September catches. Figures 10 and 11 show the mean catch rate of each species per 50 m depth zones for spring-summer and fall-winter periods. It is interesting that the high catch rates of *H. laevigatus* in depths of 550-599 m were experienced only during the October-March period. Otherwise, there is no indication that the depth range of optimum abundance for either species differed significantly between the two seasons.

Comparison With Commercial Shrimp Trapping

As part of a study to define the distribution and magnitude of *Heterocarpus* resources in the Hawaiian Islands, in 1981 two commercial fishing vessels were chartered to conduct shrimp trapping at Maro Reef (Oishi, 1983). They set a total of 9,914 traps, and had a mean catch rate of 2.47 kg of both species per trap-night. It is of interest to compare such a relatively intense effort on a commercial scale with results obtained during this survey at the four areas most intensely sampled: Necker, French Frigate Shoals, Gardner Pinnacles, and Maro Reef. The catch rates given in Table 2 are based only on trap sets made at optimum depth ranges for each

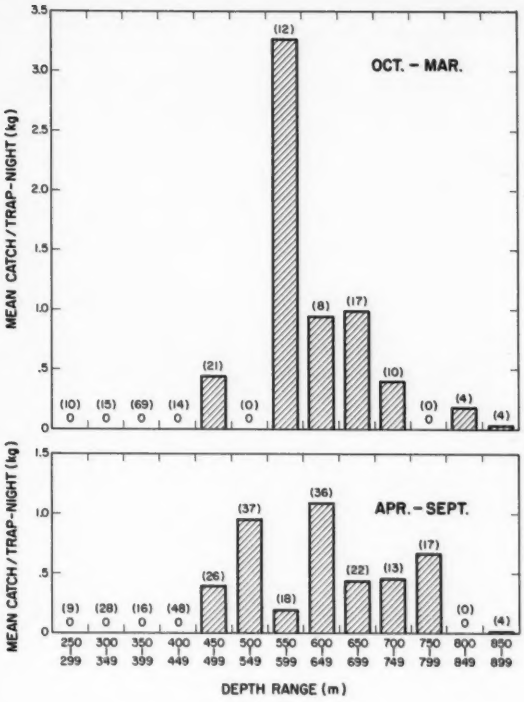

Figure 10.—Catch per trap-night of *Heterocarpus laevigatus* per 50 m depth zone for spring-summer and fall-winter seasons. Effort (trap-nights) is shown in parentheses.

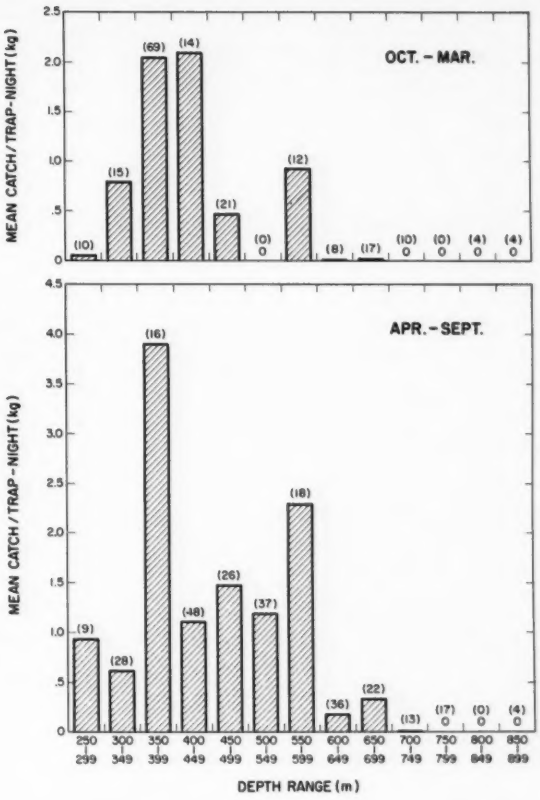

Figure 11.—Catch per trap-night of *Heterocarpus ensifer* per 50 m depth zone for spring-summer and fall-winter seasons. Effort (trap-nights) is shown in parentheses.

Table 2.—Mean catch per trap-night (kg) at optimum depth range[1].

Area	*H. ensifer*	*H. laevigatus*	Both species
Necker Island	1.65	1.18	2.83
Fr. Frigate Shoals	3.77	0.37	4.14
Gardner Pinnacles	1.17	2.09	3.26
Maro Reef	1.16	0.97	2.13

[1]350-599 m for *H. ensifer*; 500-799 m for *H. laevigatus*.

species. Highest total CPUE was obtained at French Frigate Shoals where the total mean catch as 4.14 kg per trap-night. At French Frigate Shoals 75 percent of the trapping effort was within the optimum depth range for *H. laevigatus*. Despite this, catch rates for that species were very low. The catch rate at Maro Reef was the lowest for the four fishing areas. However, the CPUE of 2.13 kg at Maro Reef was quite similar to the CPUE of 2.47 during the commercial survey in the same area. Private interests are presently conducting extensive commercial trapping for *H. laevigatus* in the NWHI. No information from these operations was available at the time of writing.

Summary

During exploratory fishing operations for the deepwater caridean shrimps *H. laevigatus* and *H. ensifer* from 1978 to 1981, both species were trapped throughout the NWHI. Based on catch rates, peak abundance occurred at depths between 500 and 799 m for *H. laevigatus* and 350 and 599 m for *H. ensifer*. For both species there was an apparent decline in size as the depth range increased from that of peak abundance to maximum depth. There was no evidence that for either species the depth range differed significantly between the northern and southern banks of the chain, or between spring-summer and fall-winter seasons.

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Procedures for Preparing Acetate Peels and Evidence Validating the Annual Periodicity of Growth Lines Formed in the Shells of Ocean Quahogs, *Arctica islandica*

JOHN W. ROPES

Introduction

Bivalve mollusks have historically been aged by examining the external valve surface for growth "rings" or "bands" that form as an annual event (Rhoads and Lutz, 1980). Although such surface features are useful for ageing some species, for others the method produces conflicting and incomplete results. This is particularly true for the ocean quahog, *Arctica islandica*, a species with a potential life span of about 225 years (Ropes and Murawski, 1983). Small ocean quahogs (shell length < 60 mm or 2⅜ inches and < 20 years of age) often exhibit definite external rings in the light brown to mahogany colored shell covering, the periostracum. The same rings formed during the earliest years in the life of large, old ocean quahogs may be discernible, but erosion often obliterates some and those near the ventral valve margin are crowded together in the uniformly black periostracum. Microscopic examination fails to reveal definite rings.

In some bivalve species, darker growth lines alternating with lighter growth increment deposits are seen in the broken edges of valves that have continuity with "bands" on the external valve surface. The development of diamond-impregnated saw blade equipment has greatly facilitated cutting bivalve shells in a directed manner for an examination of the accretion of shell layers from the beginning of their formation at the umbo to the ventral margin. Although cutting the valve is a time consuming procedure, it is believed that the internal depositional features tend to be much less affected by destructive external environmental conditions impacting on the valve surfaces and, thus, a record of growth is preserved intact. Annual microstructural deposits may also occur in other parts of the shell that can be prepared for examination by fairly rapid methods, such as was reported for the chondrophore of the surf clam, *Spisula solidissima*, by Ropes and O'Brien (1979) (Fig. 1).

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ABSTRACT—Techniques are described for producing acetate peels of radially sectioned ocean quahog, Arctica islandica, *shells to observe age and growth phenomena. Specimens marked and recovered 1 and 2 years later validated the hypothesis that growth lines are formed annually. Growth functions have been developed for quahogs from off Long Island, N.Y., and Georges Bank. The growth of the species is characterized as being slow. Some geographic and individual specimen variability in growth was observed. Sexual maturity was attained at 5-6 years of age, but varied with size and sex. Ages approaching and exceeding 100 years are not uncommon. One specimen was about 225 years old, an age greater than known longevity estimates of other bivalve species.*

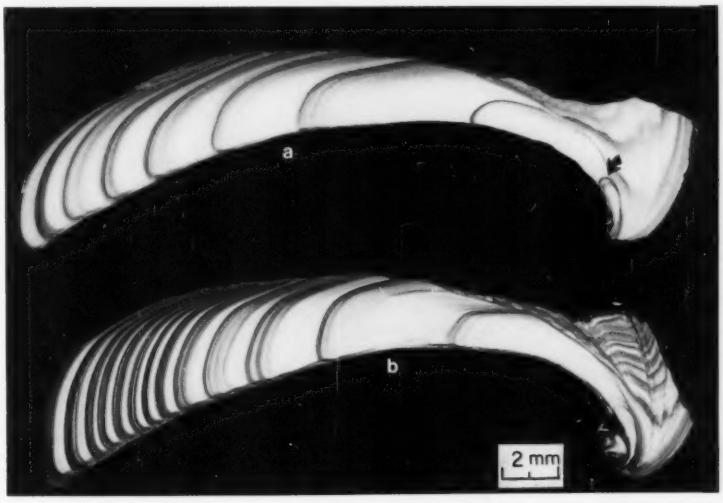


Figure 1.—Enlarged images of thin-sectioned chondrophores from two surf clams: (a) 8 years old, 139 mm (~5½ inches) in shell length, collected 16 December 1975 at lat. 36°32.5′ N, long. 75°28.8′ W, off False Cape, Va. (b) 13 years old, 137 mm (~$5^3/_{16}$ inches) in shell length, collected 12 December 1975 at lat. 38°03.5′ N, long. 75°05.0′ W, off Chincoteague, Va. The first annulus formed in the life of a surf clam is sometimes faint (an arrow points to a bold one in the chondrophore of clam (a)). The most recent annulus at the marginal edge of these chondrophores was not completely formed. A millimeter scale is included in this and subsequent figures.

Simply cutting the valves of a bivalve may not expose well defined growth lines, due to variations in the microstructure of the shell deposits. Such is the case for ocean quahogs. Kummel and Raup (1965) included techniques of preparing the cut valve surfaces and transfer of the microstructural details onto sheet acetate for fossil bivalves. The following outlines procedures that have been developed at the Woods Hole Laboratory of the NMFS Northeast Fisheries Center for preparing shells of ocean quahogs, with evidence validating the annual periodicity of annuli and summaries of recent age and growth studies.

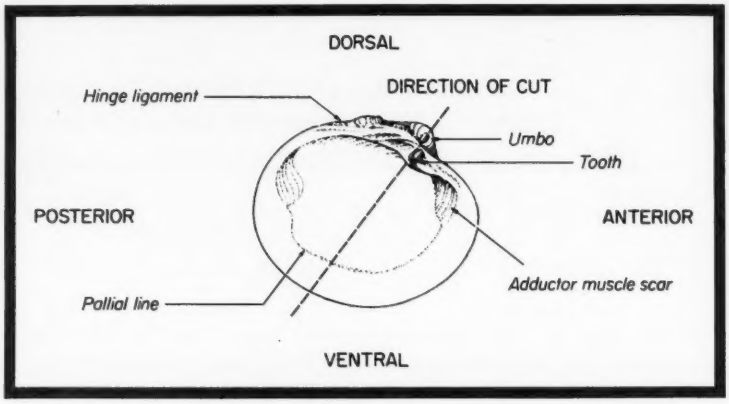


Figure 2.—The internal features of an ocean quahog shell showing the plane of section (dotted line) for orientation purposes during the sectioning operation.

Acetate Peel Method

Before processing the shells for age determinations, records of sample collection information are tabulated with measurements of paired whole valves. Figure 2 shows the internal valve features useful for orientation purposes when using vernier calipers to measure the length (longest anterior-posterior dimension), height (deepest dorsoventral dimension), and width (widest lateral dimension) to the nearest 0.1 mm. Dry shell weights are measured to the nearest 0.1 g.

Internal annuli are exposed by radially sectioning the left valve of a pair, since it is unique and contains a single prominent tooth in the hinge (Fig. 2). This tooth contains annuli useful in confirming counts made in the valve portion. A pencil mark is made at the ventral margin at a point from the posterior end equal to one-third of the valve length. The valve is then fastened with its concave, inner surfaces toward the diamond blade of a saw machine and on its adjustable arm holder with an adhesive putty. Table 1 lists sources of apparatus[1] or materials. The valve is oriented with the tooth toward the front of the saw machine to cut through the middle of the tooth or immediately adjacent to the posterior edge of the tooth and through the pencil mark at the ventral margin. The cut is made completely through the valve and the anterior portion is saved for later treatment. About 7-8 medium-sized (60-70 mm or 2⅜-2¾ inches long) or 3-4 large-sized (100+ mm or 4 inches) quahogs can be cut per hour.

Table 1.—Sources of apparatus and materials used to section, polish, embed, and produce acetate peels of ocean quahog shells.

Apparatus or materials	Source
Isomet low-speed saw machine	Buehler, Ltd.
Diamond wafering blades	41 Waukegen Road
(High concentration)	P.O. Box 1
a) 10.2 cm × 0.3 mm × 12.7 mm	Lake Bluff, IL 60044
b) 12.7 cm × 0.38 mm × 12.7 mm	
Hustler vibrating lap, 15 inches diameter	Raytech Industries
Slab-Stik (adhesive putty)	P.O. Box 6
Grind and Shine, gem finishing compounds	Stafford Springs, CT 06076
(#2, silicon carbide 800-F; #3, Syntin)	
Epon 815 resin and DTA hardener	Miller-Stevenson Chemical Co., Inc.
	P.O. Box 950
	Danbury, CT 06810
Di-acetate sheets	Commercial Plastics and Supply Corp.
19" × 24" × 0.005" thick	352 McGrath Highway
	Somerville, MA 02143
Norton, Tufbak, Durite, waterproof, closekote, silicon carbide paper.	Local hardware store
"Freezette" plastic refrigerator containers.	Local hardware store

Calcium carbonate deposits embedded in the inner surfaces of the periostracum react during a later etching step, leaving voids in the peels. These deposits and the periostracum are removed by placing valve specimens in full-strength household bleach (sodium hypochlorite ~5.25 percent) for a few hours.

Pre-embedding grinding of the cut surfaces with wetable carborundum paper (240 and 400 grit) is advisable. Remove obvious saw marks or other blemishes and grind to expose the broadest surface of the tooth. Allow the specimens to dry completely before proceeding with the next step.

The valve specimens are embedded in an epoxy resin at room temperature. Mix

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

carefully, but thoroughly (~1 minute), avoiding the introduction of bubbles, and in small amounts (50-75 ml) to minimize an exothermic reaction. Pour the mixed epoxy into plastic molds to a depth of about ½ cm. Lower the valve into the epoxy with the cut surface toward the bottom of the mold and press down to force bubbles from between the cut surface and mold bottom. Place the whole set-up in a vacuum chamber and subject to low pressure (~25 psi) for about 1 hour. This evacuates bubbles formed in the epoxy. Leave at room temperature overnight to harden.

Three successively finer grits (240, 400, and 600) of wetable carborundum paper are used to obtain a smooth surface on the embedded cut surfaces of the valves. Most of the grinding is done with the 240 grit paper to remove epoxy from the cut surfaces of the valves; the finer grits (400 and 600) are used to minimize scratches from the coarser grit papers.

A blemish-free, high-gloss surface on the cut valve surfaces is produced on a vibrating lap machine in two steps. In step one, the pad in one pan for the machine is flooded with tapwater and drained in a bucket. After clamping the pan on the machine, the pad is charged with medium grit powder (#2), the specimens placed on the pad, and the machine turned on. Lead weights (~200-300 g) can be fastened to the blocks with adhesive putty to hasten polishing. During a 1-hour period the specimens are removed, rinsed in tapwater, damp-dried, and inspected for a moderate sheen. In step two, specimens are transferred to a second pan containing a wet pad, the pad is charged with fine grit powder (#3), and the machine is operated for 1-2 hours. The final high gloss is most evident on the cut valve surface, but less so on the epoxy surface.

The polished cut edges of the valves are then etched by immersing the blocks in a 1 percent HCl solution for 1 minute, followed by rinsing in tapwater. It is essential not to damage the polished or etched surfaces. Allow the etched specimens to dry. Code numbers for each valve specimen can be scribed with a carbide-tipped pen into the polished epoxy surface near the cut surfaces. These numbers are automatically transcribed onto the acetate peel during the next step.

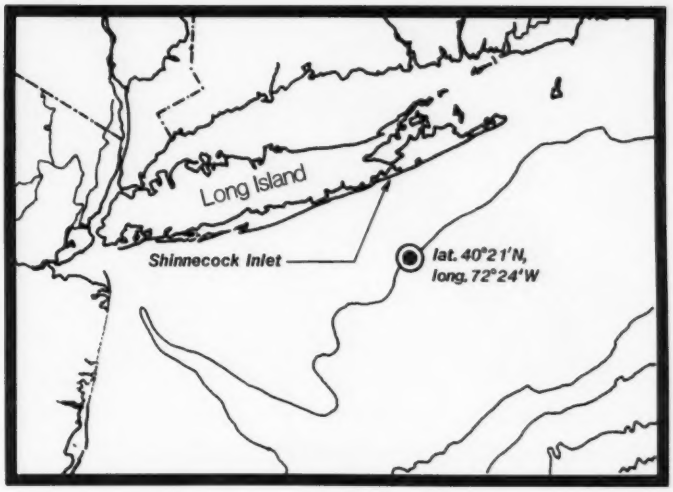


Figure 3.—Location of ocean quahogs dredged for marking and release in late July-early August 1978. Annual recoveries have been made.

Acetate peels are produced by supporting the block with the etched surfaces uppermost and level. A sheet of acetate that extends beyond the edges of the block is applied and held in place with a binder clip. The free end of the acetate is lifted, acetone is flooded onto the block surface, and the acetate sheet is lowered onto the surface. Acetone must occur between the sheet and etched surface without bubbles for a successful peel. The whole block is turned over, excess acetone is drained off, laid on a pad of paper, and pressed for about 1 minute. After a 1-hour drying period, the acetate is peeled off and sandwiched between clean glass slides for examination. Additional peels can be made without repeating the polishing and etching procedures. An acetate sheet left on the block protects the etched surface from damage during storage.

Validation of Annuli

The acetate peel technique has been used by several investigators to supply valuable evidence supporting the hypothesis of an annual periodicity of growth line deposition in ocean quahogs (Thompson et al., 1980a, b; Jones, 1980; Turekian et al., 1982). However, these studies did not include the direct and readily comprehended observations of growth after marking specimens, evidence that was necessary for a general acceptance of the hypothesis.

In 1978, the National Marine Fisheries Service conducted a marking operation at a deep-water (53 m) site 48 km SSE of Shinnecock Inlet, Long Island, N.Y. (lat. 40°25.1′N, long. 72°23.7′W) (Fig. 3). The location was chosen because it is remote from clam dredging practices in the Middle Atlantic Bight, and, from survey results, it was known to contain an abundance of quahogs of a wide size range (Murawski et al., 1982).

A commercial clam dredge vessel, the M/V *Diane Maria*, was chartered for the marking operation. The knife of the hydraulic dredge was 100 inches (2.54 m) wide and the cage was lined with ½-inch (12.7 mm) square-mesh hardware cloth to retain small clams. Ocean quahogs for marking were collected within 9 km of the planting site

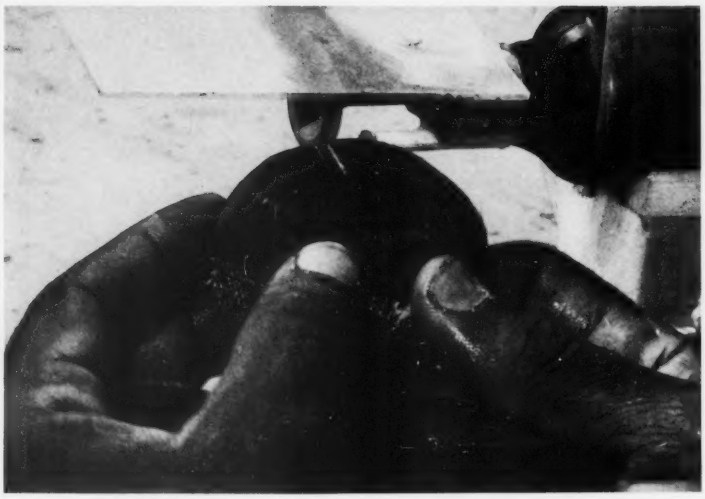


Figure 4.—Marking ocean quahogs for release off Long Island, N.Y., in 1978.

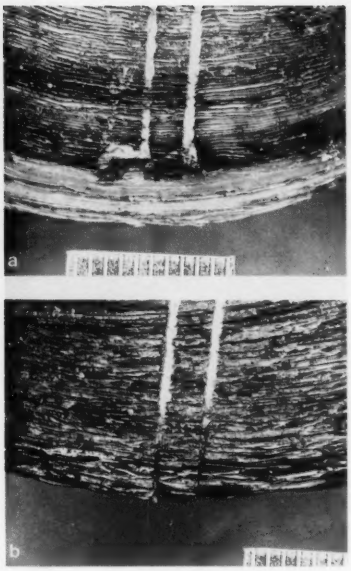


Figure 6.—(a) Enlarged view of the notches and new shell growth in the valve of the ocean quahog in Figure 4. (b) Enlarged view of the notches in the valve of an ocean quahog about 95 years old and 91.7 mm (~3 9/16 inches) in shell length recovered on 9 September 1980. The thick periostracum obscured very slight growth (~0.3 mm or 1/100 inch) attained during the 2 years after the notching operation.

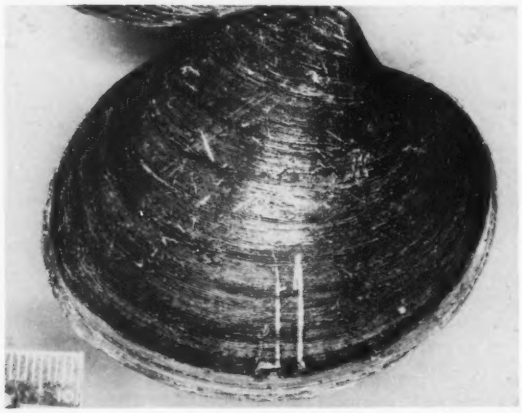


Figure 5.—Left valve of a 15-year-old ocean quahog, 60.0 mm (~2⅓ inches) shell length, recovered on 9 September 1980 2 years after marking and release. The notch marks and growth thereafter show clearly at the valve margin. Estimated growth was 3.5 mm (~⅛ inch).

and released during a 10-day period (~17,000 on 26 July, 3,000 on 2 August, and 21,000 on 4 August 1978). Two 0.7 mm thick carborundum discs spaced 2 mm apart and mounted in the mandrel of an electric grinder produced distinctive parallel, shallow grooves from the ventral margin up onto the valve surface (Ropes and Merrill, 1970) (Fig. 4). Four operators of grinders marked about 1,600 clams per hour. Groups (~3,000-8,000) of marked clams were released at Loran C coordinates within a rectangular area of about 3 by 6 microseconds.

Marked clam recoveries were made in conjunction with annual clam resource surveys. During recovery operations, a Northstar 6000 Loran C unit and Epsco Loran C plotter aided in a systematic search of the planting site. Marked clam recoveries were highly variable. On 20 and 21 August 1979 and about 387 days after the marking operation, 43 hydraulic dredge tows at the planting site captured 14,043 ocean quahogs, and 74 (0.5 percent) were marked; on 9 September 1980 and about 773 days after the marking operation, 1,899 ocean quahogs were captured in two dredge tows, and 249 (13.1 percent) were marked. Some marked specimens were damaged, but 67 recovered in 1979 and 200 recovered in 1980 were alive and had intact paired valves.

The parallel groove marks in the wet shells were easily recognized during recovery operations (Fig. 5). New shell was more obvious at the valve margin of smaller, younger clams, since readily

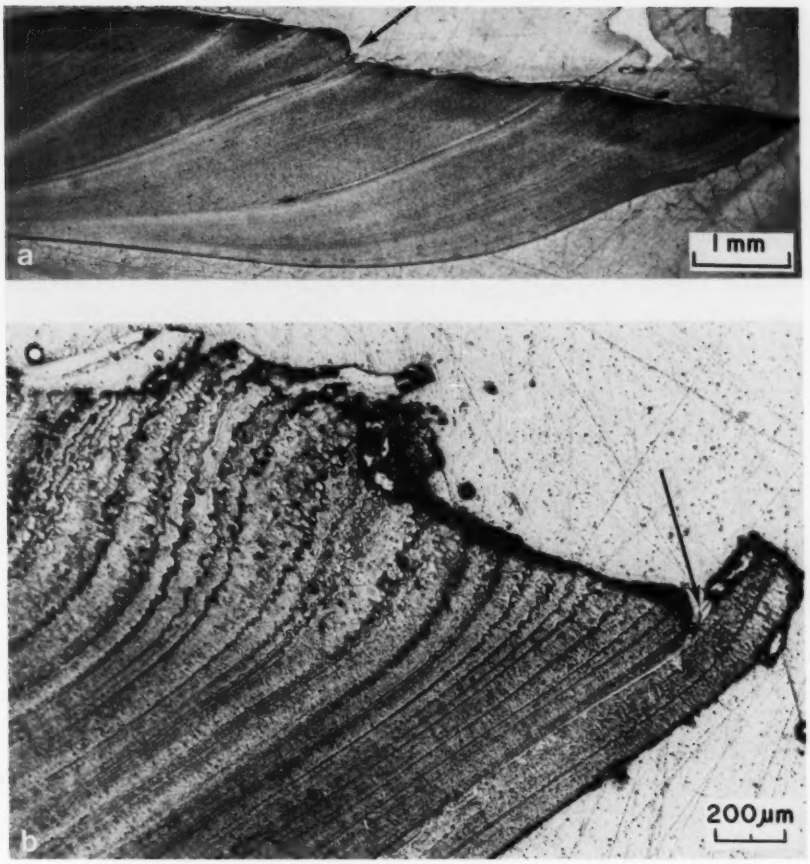


Figure 7. — Photomicrographs of acetate peels showing growth and annuli at the valve margins of the ocean quahogs used in Figures 4 and 5. (a) Three annuli in the younger quahog. An arrow points to the annuli formed soon after marking the clam. (b) Many repetitive annuli in the older quahog. An arrow points to an interruption of growth and annuli formed at or soon after marking the clam. The flattened area was produced by the notching operation. This clearly separated shell growth and annuli formed before and after the notching operation. Note that only one additional annulus was formed by both quahogs during the 2 years they were free in the natural environment, but that two increments of shell growth had been accreted.

visible growth had occurred after marking, as seen by a lighter, yellowish-brown coloration of the periostracum that usually contrasted sharply with the earlier, slightly darker layer (Fig. 5 and 6a). In old ocean quahogs the dark black periostracum obscured new shell growth (Fig. 6b). In all sizes of mark-recaptured quahogs, acetate peels showed definite increments of growth and annuli formed after marking that were consistent with an annual periodicity (Fig. 7a, b). Specific microstructures have been identified and described for the annuli and growth increments (Ropes et al., In press, a).

Application of the Technique

Based on finding an annual periodicity of annuli in marked ocean quahogs, Murawski et al. (1982) generated growth functions for two sources of age data. Internal growth lines in cross-sectioned valves were used to locate external bands on the valves for measurements of growth at each age in 134 unmarked ocean quahogs 19-60 mm (~¾-2⅜ inches) in shell length that were collected during the marking operation and the growth of 67 marked quahogs

(59-104 mm or ~2⅜-4⅛ inches) recaptured 1 year after marking. The growth function of backcalculated increments at age was described by $SL = 75.68 - 81.31\ (0.9056)^t$, where SL is shell length in millimeters and t is age in years; the growth function of recaptured marked specimens was described by $SL_{t+1} = 2.0811 + 0.9802\ SL_t$. Figure 8 shows the predicted shell lengths at age for ocean quahogs at the Long Island marking site. Growth was characterized as slow; at age 10 annual increases in shell length were 6.3 percent, at age 50, 0.5 percent, and at age 100, only 0.2 percent.

Age determinations of ocean quahogs by the acetate peel technique have permitted analyses of temporal relationships with growth and comparison of growth between areas inhabited by the clam. Murawski et al. (1982) developed a length-weight (drained meat) equation and derived an age-weight relationship for quahogs from the Long Island marking site. Weight gains were initially greater than length increases at young ages, but were nearly equal at the oldest ages. At age 10 mean weight increased by 18.1 percent, but at age 100 the increase was only 0.2 percent.

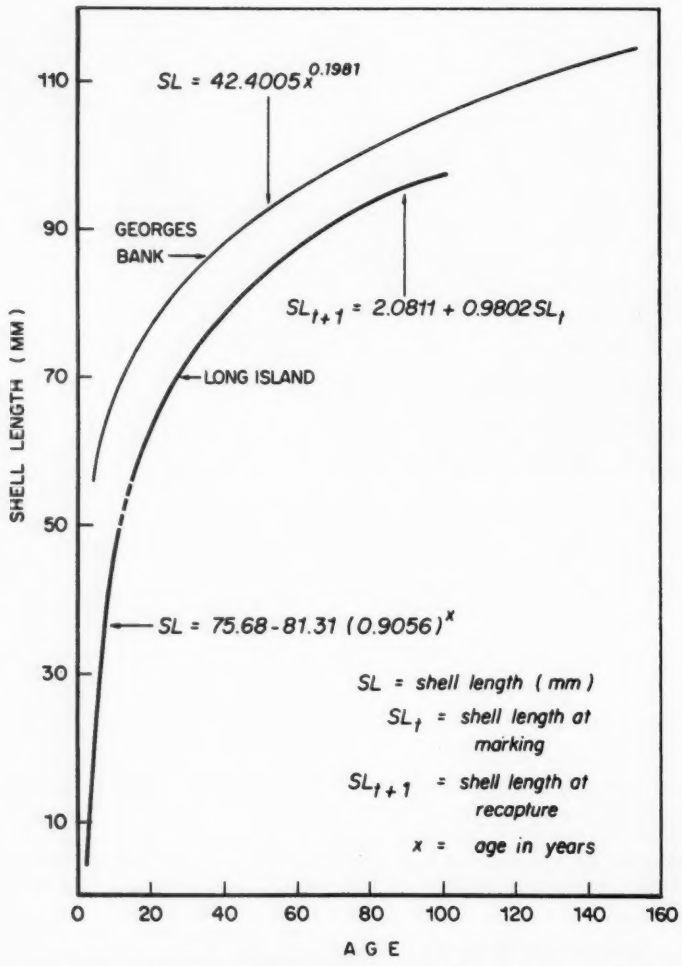


Figure 8.—Age vs. shell length of ocean quahogs off Long Island, N.Y., and from Georges Bank.

Ropes et al. (In press, b) collected small ocean quahogs from the vicinity of the Long Island marking site to determine sex and gonadal condition. Microscopic examination of histologically prepared tissues of clams 19-60 mm (~¾-2⅜ inches) in shell length revealed that 36 were immature and could not be sexed, but that sexual differentiation was evident in 97. Sixty-nine of the latter were in two types of intermediate development: Those with sparse tubule development (20); and those with moderate tubule development (49). Only 28 clams were fully mature. Age and growth were assessed from acetate peels of shell cross sections for a relationship with gonadal conditions. Immature quahogs 8 years old were found, but most averaged 5 years old, and were from 19 to 46 mm (~¾-1$^{13}/_{16}$ inches) in shell length and averaged 34 mm (~1⅜ inches). Mature males were 5 or more years old and 36 mm (~1$^{7}/_{16}$ inches) in shell length or larger; females were 6 or more years old and 41 mm (~1⅝ inches) or larger. Slightly younger and smaller quahogs were in the intermediate gonad developmental stages. The attainment of sexual maturity at age/size was variable. Determinations of sex of these and specimens 57-103 mm (~2¼-4⅛ inches) in shell length collected from the same area in 1980 indicated that the smallest and youngest ocean quahogs were predominantly male, but the largest and oldest were predominantly female.

Young ocean quahogs typically have a light brown to mahogany colored shell covering that darkens to black with increasing size and age (hence, the common names mahogany and black quahog, respectively). The brown or mahogany coloration persisted in intermediate and some large ocean quahogs collected in 1980 from southern Georges Bank and the condition was immediately recognized as being unlike that seen for ocean quahogs of similar sizes from the Middle Atlantic Bight area (Ropes and

Pyoas, 1982). This obvious dissimilarity suggested that age and growth characteristics of ocean quahog populations on Georges Bank may be different from those of other geographic areas.

The shells of 82 ocean quahogs from Georges Bank were prepared for age analysis and the average length at age was compared with similar growth data of quahogs from off Long Island. A growth curve fitted to the Georges Bank data and plotted along with a growth curve of the Long Island data indicated a much slower growth rate for the latter area (Fig. 8). A few shells of ocean quahogs were also available from off Sable Island, Canada. These provided age observations from a third geographic area for comparison with quahogs of the same size from the other two areas, but were too few to construct a growth curve. Georges Bank quahogs were clearly younger than those from off Long Island or Sable Island; Sable Island quahogs were the oldest. For example, an ocean quahog 100 mm (~4 inches) in shell length from Georges Bank and one the same size from off Long Island were 40 and 110 years old; quahogs 52 and 54 mm (~2 inches) in shell length from Georges Bank and Sable Island were 4 and 13 years old; and a Georges Bank quahog 73 mm (~2⅞ inches) in shell length and a Long Island quahog 72 mm (~2¾ inches) in shell length were 16 and 24 years old, respectively (Fig. 9).

A longevity of about 150 years reported for the ocean quahog, *Arctica islandica*, by Thompson et al. (1980a, b) was a startling discovery. Life span estimates of a few invertebrates, including the freshwater mussel, *Margaritana margaritana*, of not over 100 years have been made (Comfort, 1956). Zolotarev (1974), Zolotarev and Ignat'ev (1977), and Zolotarev and Selin (1979) found from examinations of the shell structure, analyses of an oxygen-isotope method, and notching experiments that the Far East mussel, *Crenomytilus graynus*, may exceed 100 years of age; Turekian et al. (1975) found from radiometric analyses and counting internal growth bands that a deep sea nuculoid bivalve, *Tindaria callistiformis*, only 8.4 mm in shell length, may be about 100 years old.

The estimate of longevity by Thompson et al. (1980a) was of an ocean quahog 88 mm (~3½ inches) in shell length. Much larger maximum shell lengths are attained. Murawski and Serchuk (1979) analyzed shell length-meat weight relationships of 2,564 ocean quahogs collected during a winter 1978 assessment survey throughout the Middle Atlantic continental shelf. Specimens with a maximum shell length of 131 mm (~$5^{3}/_{16}$ inches) were found. Although the shells of these quahogs were not saved, three unusually large ocean quahogs were saved from the clam assessment surveys and a fourth was provided by commercial fishermen (Table 2). All were alive when caught. Shell erosion destroyed some of the earliest annuli. Therefore, age determinations are minimum values.

Table 2.—Ages of unusually large ocean quahogs.

Sample date	Location		Depth (m)	Shell dimensions				Valve thickness (mm)	Age (years)
	Latitude	Longitude		Length (mm)	Height (mm)	Width (mm)	Weight (g)		
14 Feb. 1977[1]	39°55′	73°31′	38.4	132.0	121.2	71.5	412.7	7.0	157
7 Dec. 1978[1]	39°30′	73°19′	34.7	130.0	111.5	61.6	244.6	3.2	53
11 Aug. 1982[2]	40°34′	68°56′	69.0	130.0	119.0	63.2	310.8	4.8	93
Fall 1980[3]	41°06′	70°54′	36.6	107.2	95.2	68.3	397.7	12.3	221

[1]The earliest 2-3 annuli in the hinge tooth were missing, but all in the valve were present.
[2]The earliest 2-3 annuli in the hinge tooth were missing and 1-2 of the earliest annuli in the valve were missing.
[3]The earliest 3-5 annuli in the hinge tooth were missing and 2-3 of the earliest annuli in the valve were missing.

The ages of the three very large ocean quahogs were surprising, because only one slightly exceeded the longevity value reported by Thompson et al. (1980a). It was the 132 mm (~5¼ inches) in shell length quahog from off central New Jersey that was estimated to be 157 years old (Table 2). Another 130 mm (5⅛ inch) quahog from off central New Jersey was only 53 years old and the third from Georges Bank was 130 mm in shell length and 93 years old. The age and growth of ocean quahog populations from off New Jersey have not been investigated. Thus, the observations for the two New Jersey specimens may only represent unusual growth.

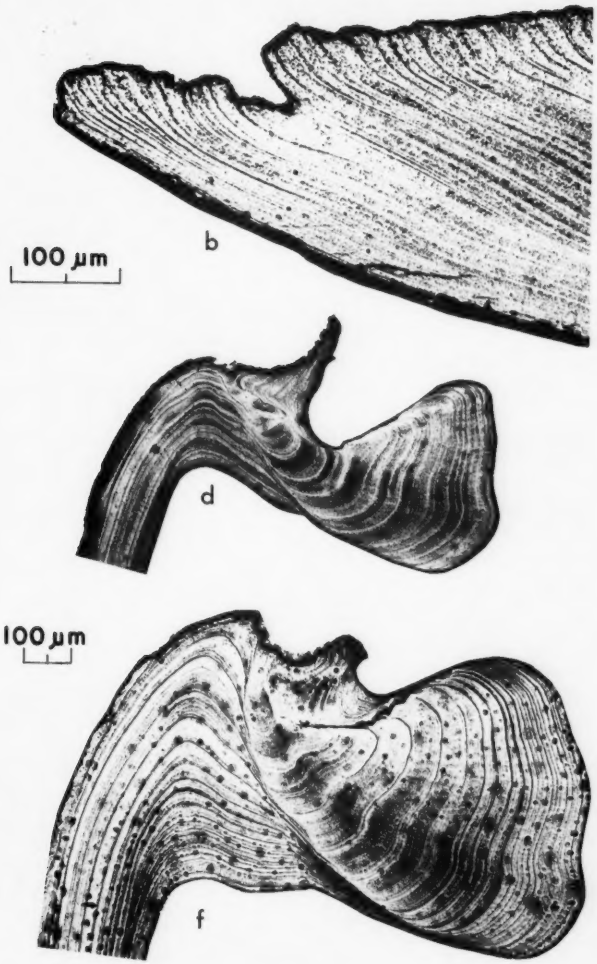
The heavily shelled ocean quahog from south of Noman's Land in southern Massachusetts water was smaller than the other three clams, but had a somewhat more globose shape (Table 2). Its shell weight was 397.9 g (~14 ounces), which is nearly equal to the 412.7 g (~14.6-ounce) weight of the largest (132.0 mm) clam examined. Part of the shell weight was due to thickening of the valve, especially beneath the hinge plate which measured 13 mm. This was more than twice as thick as was measured for the youngest (53-year-old) clam caught in 1978. About 90 percent of the thickening was of the inner shell layer. The outer shell layer became increasingly prominent with growth, although ventral to the pallial line it was no more than 4 mm thick. No apparent blunting of the ventral margin was observed, a characteristic sometimes seen in large, old hard-shelled clams, *Mercenaria mercenaria* (Dall, 1903; Belding, 1912). This clam was estimated to be 221 years old.

These observations are largely anecdotal, but they emphasize the potential for considerable variability in the size/age relationship and longevity of ocean quahogs. The variability appears to be most extreme at large size. Specific conditions for fast growth, large size, and very old age of ocean quahogs are unknown. Nevertheless, longevity for the species is substantially greater than reported by Thompson et al. (1980a) and may even be slightly higher than the 221 years given herein, since the earliest annuli were eroded and the clam was alive when captured.

Discussion

The acetate peel technique has proven to be invaluable for providing age determinations of ocean quahogs. However, its application is labor intensive. Nevertheless, segments of the populations have been aged, gaining insight

Figure 9.—Valve tip of *Arctica islandica* (a) from Georges Bank, 100.0 mm
N.Y., 100.3 mm (~ $4\frac{1}{16}$ inches) in shell length and 110 years old. Upper sc
photomicrographs. Hinge tooth of *Arctica islandica* (c) from Georges Bank,
Island Bank, 52.1 mm (~ $2\frac{1}{16}$ inches) in shell length and 13 years old. Hinge
in shell length and 16 years old, and (f) from off Long Island, New York, 7



0 mm (~ 4 inches) in shell length and 40 years old, and (b) from off Long Island, per scale bar shows enlargement of a and b; lower scale bar is for the remaining Bank, 53.9 mm (~ 2⅛ inches) in shell length and 4 years old, and (d) from Sable Hinge tooth of *Arctica islandica* (e) from Georges Bank, 73.2 mm (~ 2⅞ inches) ork, 72.1 mm (~ 2¾ inches) in shell length and 24 years old.

into age relationships of this important bivalve.

The observed differences in growth rate between geographic areas indicate that a generalized growth curve may not be strictly applicable throughout the extensive range of the species. Along the North American coast, it occurs from off Cape Hatteras, N.C., to off Newfoundland, Canada, and it also occurs off Iceland, the Faroe and Shetland Islands, and along the European coast from off Spain to the White Sea in Russia (Ropes, 1979b).

For population assessment studies, it is desirable to age large numbers of specimens throughout the extensive potential fishing areas in the Middle Atlantic Bight and off southern New England, a goal that is thwarted by the labor-intensive nature of shell preparation and microscopic examination required to age ocean quahogs. Preparation of shells for ageing are in progress for samples taken 1981-83 from marked quahogs off Long Island and samples taken from Georges Bank in 1982. The challenge for future studies is to expand sampling in areas being fished. The U.S. resource is presently regulated by a fishery management plan developed by the Mid-Atlantic Fishery Management Council with annual quotas of 40-60 million pounds of meats (MAFMC, 1981). It has been hypothesized that harvested areas would probably recover slowly due to the slow growth rate of ocean quahogs (Murawski and Serchuk, 1980). Analyses of age composition and growth in such areas may provide a basis for evaluating recovery.

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Evaluation of Methods to Determine the Proportions of Fillets and Minced Fish Flesh in Mixed Fish Blocks

J. PERRY LANE and THOMAS J. CONNORS

Introduction

Some foreign countries, most notably Norway, Germany, and Great Britain, add minced fish to fillet blocks. It is claimed that the binding properties of the minced fish reduce breakage during the manufacture of fish sticks and portions from these blocks, as well as making more complete use of the fish by recovering flesh from trimmings and other waste generated by the filleting operation. Currently, the United States Standards for Grades of Frozen Fish Blocks make no provision for grading mixed fillet-mince blocks. Blocks may be all fillets or all minced fish but not a mixture of the two.

Some U.S. producers of fish sticks and portions have expressed an interest in using mixed fillet-minced fish blocks and requested the U.S. Department of Commerce's National Marine Fisheries Service (NMFS) (preparing agency for the U.S. Grade Standards for Fishery Products) to develop a Grade Standard for mixed blocks. Since establishing some level of minced fish content will be an important quality criteria, it becomes necessary to select or develop a method for determining the amount of minced fish in the block.

To facilitate the development of Grade Standards, NMFS has a policy of establishing a technical working group for each standard. The group is made up of both government and industry representatives, the latter being from the segment of the fish industry connected with the product under consideration. In the case of the Fish Block Technical Working Group, a subcommittee on methodology was formed for the express purpose of working with the NMFS Northeast Fisheries Center's Gloucester Laboratory to evaluate, refine, or devise and recommend a method of determining the amount of minced fish in a mixed fillet-mince block. The committee and Laboratory personnel identified four methods for evaluation. One was from the Federal Republic of Germany (FRG) while the other three were Norwegian.

The methods were first screened for ease of use and adaptability to a production, or large-scale sampling situation. This report gives the results of the screening process for the four methods. For identification purposes, the methods are designated as FRG[1], Norwegian[2], Modified Norwegian[3], and Bergen[4].

Materials

Fifty mixed fillet-mince blocks were obtained from Norway through the cooperation of Robert Tinay of Frionor Kitchens, Inc., of New Bedford, Mass. These blocks were from a normal production run and were reported to contain an average of 20 ± 5 percent minced fish. It should be emphasized that we did not require a precise known amount of minced fish since our primary interest at this stage was to evaluate the methods for practicality of use. The most practical method would then be selected, modified if needed, and then evaluated for accuracy. The procedure used and the results obtained will be given for each method.

FRG Method

Procedure

Principle

Frozen subsamples are placed in a watertight bag and thawed in water. After the thawed fish is drained and weighed, the fillets are held with a fork while the minced fish is scraped off with a spatula. The minced fish and fillets are collected separately, weighed, and the proportion of each calculated.

Apparatus

1) A water bath set at 20°-25° C (70°-80° F);
2) U.S. No. 8 Standard sieve;
3) Fork and rubber-edged spatula;
4) Balance sensitive to 0.28 g or 0.01 ounce.

Determination

While the fish block is still frozen, cut two 1 kg (2-pound) samples from opposite ends and two 1 kg (2-pound) samples from the middle of the block. The total weight of the sample should be at least 4 kg (8 pounds). Weigh the sample on a

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[3]G. R. Tinay, Frionor Kitchens, Inc., Herman Melville Blvd., New Bedford, MA 02741. Pers. commun.
[4]J. Gjerde, Sentrallaboratoriet Fiskeriidirektoratet, mollendalsvegen 4, postboks 185, 5001, Norway. Pers. commun.

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scale of adequate capacity with a sensitivity of 0.28 g (0.01 ounces) (weight = A). Cut the sample into portions weighing ~100 g (3.5 ounces). Place each portion in a watertight plastic bag of suitable size. Thaw the portions in a water bath at ~20°C (70°F) but not over 25°C (80°F) with gentle agitation of the water.

After thawing has been completed, take each portion, one at a time, and drain the exuded fluid (thaw drip) for 2 minutes on a preweighed U.S. No. 8 Standard circular sieve inclined at an angle of 17°-20°. Determine the weight of the flesh (weight B) using a scale of adequate capacity with a sensitivity of 0.28 g (0.01 ounces). Place the flesh on a plate and separate the minced flesh from the fillet flesh, using a fork to hold the fillet flesh and a soft, rubber-edged spatula to scrape off the minced flesh. Then weigh the fillet part (weight = C) and the minced part (weight = D) separately. After completing the separation of each thawed portion, add the weights of the fillet flesh and the minced flesh. To each sum add one-half the weight of the exuded fluid (thaw drip) (A − sum of B = E).

Calculations

1) Net weight of sample (A) − total frozen weight of all four portions of the sample;

2) Net weight of thaw drip (E) − weight of the frozen sample − weight of thawed-drained sample;

3) Percent minced fish (M) =

$$\left[\frac{\text{Net weight of mince } (D) + \tfrac{1}{2} \text{ weight of thaw drip } (E)}{\text{Net weight of sample } (A)}\right]$$

× 100, or

$$M = \left[\frac{D + \frac{E}{2}}{A}\right] \times 100.$$

Results and Discussion

The sample was obtained by cutting four pieces weighing ~1 kg each from one 16-pound block. After the four pieces were weighed, each was cut into 10 pieces of ~100 g each. The 100 g portions were placed individually in plastic pouches and thawed in a water bath maintained at 22°C. After the portions were thawed, they were drained and the minced fish separated from the fillets according to the procedure described under "Determination". The results appear in Table 1.

Table 1.—Percent minced fish found in a sample of mixed fish-mince block using the FRG procedure.

Weight (g)					
Sample weight (A)	Drained weight (B)	Fillet weight (C)	Mince weight (D)	Thaw drip $A - B$ or (E)	Percent mince
3,610	3,267	2,991	276	343	12.4

The cutting, thawing, and separation of the 40 portions of ~100 g each into minced fish and fillets was very time-consuming. Nearly 4 hours were required to do the one sample. The percent of minced fish was found to be 12.4, well outside the reported range of 15-25 percent. Since only about one-half the fish block was used, the sample may not be representative of the true proportion of mince present in the block.

It was concluded that this method was too time-consuming to lend itself to a large-scale testing situation. Therefore, no further samples were analyzed using this method.

Norwegian Method

Procedure

Principle

An air-thawed fish block sample is separated by hand, drained, and weighed. After the drained weight is obtained, the sample is placed on a tray with 12 mm holes and the minced fish removed with a water spray. The remaining fillets are drained and weighed and the percent of minced fish calculated.

Apparatus

1) U.S. No. 8 Standard sieve, 30 cm (12 inches) in diameter;

2) Balance sensitive to 0.28 g (0.01 ounce);

3) Perforated tray with 12 mm holes;

4) Water spray nozzle to deliver a gentle water spray.

Determination

The sample size is at least 5 kg (10 pounds) or preferably an entire fish block. Thaw the sample. The thawed sample should not be held for more than 8 hours before examination.

After thawing has been completed, take some of the fillets or fillet sections (pieces), place in single layer, and drain the exuded fluid (thaw drip) for 2 minutes on a preweighed U.S. No. 8 Standard circular sieve inclined at an angle of 17°-20°. Use a 20 cm (8-inch) sieve for <0.9 kg (2 pounds) of fish flesh and a 30 cm (12-inch) sieve for larger quantities up to the capacity of the sieve to hold a single layer of fillets or fillet sections (pieces). Determine the weight of the drained flesh (weight A) using a scale of adequate capacity with a sensitivity of 0.28 g (0.01 ounce).

Place the flesh on a tray perforated with holes of 12 mm diameter. Spray the flesh with a gentle spray of cold water until no further minced fish flesh will pass through the holes. A soft, rubber-edged spatula may be used to help scrape off the minced fish flesh. Transfer the remaining fish material to a preweighed No. 8 sieve, incline it at an angle of 17°-20°, and allow it to drain for 15 minutes. Weigh the remaining fish material (weight = B).

Calculations

1) Net weight of sample (A) − total weight of all drained fish flesh;

2) Net weight of fillets (B) − total weight of all drained fillet material after separation from mince with a water spray;

3) Percent minced fish (M) =

$$\left[\frac{\text{Net weight of sample } (A) - \text{net weight of fillets } (B)}{\text{Net weight of sample } (A)}\right]$$

× 100, or

$$M = \left[\frac{A - B}{A}\right] \times 100.$$

Results and Discussion

Ten fish blocks were examined by this method. The sample unit was the entire fish block. The blocks were thawed overnight on trays at room temperature (68°F or 20°C). The thawed blocks were individually separated and drained and the net weights obtained. Then the minced fish was separated by hand from the fillets with a water spray and the hands (no spatula used); otherwise the procedure given in "Determination" was followed. The water spray was used at the rate of 2 gallons/minute. It required 7 hours to run all 10 blocks at an average of 42 minutes/block. The results are given in Table 2.

Table 2.—Percent minced fish found in ten samples of fish blocks using the Norwegian procedure.

Block no.	Weight (pounds) Frozen block	Drained block	Drained fillets	Percent minced fish
1	16.6	14.98	10.99	26.6
2	16.6	15.65	11.21	28.3
3	16.6	15.34	12.85	16.2
4	16.5	15.10	12.51	17.2
5	16.6	15.36	11.57	24.7
6	16.6	16.12	11.10	31.1
7	16.6	15.80	10.65	32.6
8	16.6	14.65	11.55	21.2
9	16.6	15.07	10.61	29.6
10	16.3	14.17	10.73	24.3
			Mean	25.2%
			Range	16.2-32.6
			S.D.	5.6
			Variance	28.3

The mean percent mince, 25.2, was just above the reported upper limit of the added minced fish content of 25 percent. The time required, 42 minutes/block, appears too great to be of practical value as a production test method.

Modified Norwegian Method

Procedure

Principle

A fish block is air thawed, drained, and the net weight determined. The block is immersed in a cold-water bath and the fillets are separated from the mince by hand. The fillets are placed on an inclined tray, and the excess water is removed and weighed. The proportion of minced fish is calculated from the drained weight of the block and the fillets.

Apparatus

1) Shallow trays large enough to hold one fish block for thawing;

2) Container large enough to hold one fish block plus ~5 gallons of water;

3) Balance sensitive to 0.28 g or 0.01 ounce.

Determination

The sample size is an entire fish block. Thaw the sample on a preweighed tray in air at ambient (room) temperature (this generally takes overnight). After the block has thawed completely, it should not be held for more than 8 hours before examination. Drain the exuded fluid (thaw drip) by inclining the tray at an angle of 17°-20°. Determine the weight of the drained flesh (weight = A) using a scale of adequate capacity with a sensitivity of 0.28 g (0.01 ounce).

Immerse the drained flesh in a tub of cold tapwater. Separate the fillets by hand and wash the minced fish flesh from the fillets. Place the washed fillets on the upper section of a preweighed tray which is inclined at an angle of 17°-20°. Allow the fillets to drain for 15 minutes. Remove the wash water from the lower section of the tray, then weigh the drained fillets (weight = B) using a scale of adequate capacity with a sensitivity of 0.28 g (0.01 ounce).

Calculations

1) Net weight of sample (A) is the weight of the thawed, drained fish block;

2) Net weight of fillets (B) is the weight of the drained fillets after they have been separated from the minced fish in the water bath;

3) Percent minced fish (M) =

$$\left[\frac{\text{Net weight of sample } (A) - \text{fillet weight } (B)}{\text{Net weight of sample } (A)}\right] \times 100, \text{ or}$$

$$M = \left[\frac{A-B}{A}\right] \times 100.$$

Results and Discussion

Ten blocks were examined by this method. The blocks were thawed overnight on preweighed aluminum trays, ambient temperature 70°F (21.1°C). The blocks were drained, weighed, and placed in a container of cold water. It was found that a ratio of about two parts water to one part fish (4 gallons of water to one 16-pound block) provided enough water to satisfactorily wash the minced flesh from the fillets. The fillets were drained and weighed according to the procedures given in the "Determination" section.

About 4 hours were required to analyze the 10 blocks or about 24 minutes/block. Considerable time was spent in waiting for the mandated drain periods to be completed. The results appear in Table 3.

Table 3.—Percent minced fish in ten fish blocks using the Modified Norwegian procedure.

Block no.	Weight (pounds) Frozen block	Drained block	Drained fillets	Percent minced fish
1	16.1	14.96	13.21	11.7
2	16.9	16.32	13.57	6.8
3	16.1	16.29	13.87	14.9
4	16.1	15.02	12.91	14.0
5	16.1	15.55	12.62	18.8
6	16.9	15.42	13.26	14.0
7	16.1	14.88	12.11	18.6
8	16.1	16.07	11.92	25.8
9	16.1	15.50	10.93	29.5
10	16.1	15.15	10.64	29.8
			Mean	19.4%
			Range	6.8-29.8
			S.D.	6.6
			Variance	39.7

The mean percent, 19.4, was very close to the reported mean, 20 percent, of the lot of fish blocks. The method required no special equipment, was simple, and the time was the best of any of the four methods tested.

Bergen Method

Procedure

Principle

Samples of frozen fish blocks are placed in plastic bags and thawed in cold

water. The samples are drained and net weight is determined. The sample is mixed with water and poured into stacked sieves. A water spray is used to separate minced fish from fillets. The fillets are retained on the coarse sieves (the mince on the smallest one). Composition of the sample is calculated using the combined fillet weight of the three coarser sieves.

Apparatus

1) A set of sieves containing 5, 12, 20, and 50 mm holes, respectively. Perspex is recommended as a suitable sieve material. The distance between the holes should be equal to or slightly greater than the diameter of the holes. The sieves should be strong enough and have an area large enough to hold at least 3 kg (6.6 pounds) of fish in a single layer of fillets;

2) A frame to hold the sieves, with 50 mm sieve on top, the 20 mm sieve below it, the 12 mm sieve below the 20 mm sieve, and 5 mm sieve below the 12 mm sieve;

3) A water sprinkler which provides a suitable area of spray and a delivery of 5-10 gallons (20-40 l) of water/minute;

4) A scale of adequate capacity with a sensitivity of 0.71 g (0.025 ounces).

Determination

The sample size is at least 4-6 kg (8-12 pounds) cut in ~1 kg (2-pound) units from four or more representative locations of a fish block.

Thaw the frozen sample in cold water in a plastic bag overnight in a refrigerator (~2°C or 36°F), drain for 15 minutes on a wire mesh screen inclined at an angle of 17°-20°. Weigh the drained sample (weight = A). Thawed sample should not be held more than 8 hours before examination.

Calculations

1) Net weight of sample is the weight of the thawed, drained block (A);

2) Net weight of the fillets is the sum of the weight of the fillets on the 50, 20, and 12 mm sieves ($B + C + D$);

3) Percent minced fish (M) =

$$\left[1 - \frac{\text{Net weight of fillets } (B + C + D)}{0.96 \text{ Net weight of sample } (A)}\right] \times 100, \text{ or}$$

$$M = 100 \times \left[1 - \frac{B + C + D}{0.96\ A}\right]$$

Results and Discussion

Instead of using the 8-12 pound sample unit called for, we used the entire 16-pound fish block. The sieves were made by drilling holes in aluminum trays 26 × 18 inches. A total of 10 samples were analyzed. In doing the first sample, it was found that placing the fish block in a plastic bag in 36°F water resulted in complete glaze over the block after 12 hours. It was necessary to spray the block several minutes to remove the glaze. The block was only partially thawed. We also found that a spray of even 2 gallons/minute to separate the mince from the fillets was too strong and some of the fillets were forced off the sieves.

For the remaining 9 blocks, tap water at 52°F was used and the thaw time extended to 15 hours. Even under these conditions there was some ice glaze on the blocks and it was necessary to add warm water to each pan to remove the glaze. It required 1 hour and 20 minutes to do the first block and 9 hours and 45 minutes to do the other nine blocks (1 hour and 5 minutes per block). The results of this examination appear in Table 4.

The mean percent minced, 22.6, was well within the reported range of minced fish content for the blocks. Special equipment was required in the form of a set of four sieves and a frame to hold them, refrigeration facilities, and pan to hold the water and blocks for thawing. Over an hour was required to do the examination on one block.

Conclusions

Four methods for determining the proportions of minced fish in a mixed fillet-mince fish block were evaluated. This evaluation was to determine the suitability of the methods for use in in-plant production situations or where relatively large numbers of samples would be examined. At this stage, the accuracy of the method was not a primary consideration since the actual content of minced fish in each block tested was not known. For ease of identification, the four methods were designated FRG, Norwegian, Modified Norwegian, and Bergen.

The FRG and the Bergen methods were deemed unsuitable because of the excessive time required to make the determination. The FRG method had the further disadvantage of requiring the preparation of 40 small subsample units for each sample and the use of a water bath. The Bergen method required refrigeration facilities, an excessively long thawing period, and four sieves plus a stand or rack to hold them.

Of the two remaining methods, the Norwegian and the Modified Norwegian, the latter was considered the most practical and was selected for further evaluation of its accuracy. The Modified Norwegian method required the least time to carry out and was also most accurate with a mean of 19.4 percent reported for the lot of blocks of 20 percent minced fish. The next phase of this study will be to consider possible refinements to the method and testing it for accuracy on blocks of known minced fish content.

Table 4.—Percent minced fish found in ten samples of fish blocks using the Bergen procedure.

Block no.	Weight (pounds) Frozen block	Drained block	Drained fillets	Percent minced fish
1	16.42	16.33	11.72	25.2
2	16.47	17.05	14.08	14.0
3	16.45	16.63	12.17	23.7
4	16.52	16.69	12.02	25.0
5	16.52	16.63	12.92	19.0
6	16.44	16.81	11.59	28.2
7	16.53	17.16	12.47	24.3
8	16.27	16.34	12.44	20.7
9	16.58	16.88	13.78	14.9
10	6.27	16.06	10.52	31.8
			Mean	22.6%
			Range	14.0-31.8
			S.D.	5.6
			Variance	28.4

Relationship Between Honeycombing and Collagen Breakdown in Skipjack Tuna, *Katsuwonus pelamis*

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ABSTRACT—Honeycombing, a condition that affects the connective tissue, was studied in skipjack tuna under controlled conditions over a wide range of temperatures. A numerical scale used to measure honeycomb formation was closely correlated with the amount of collagen solubilized during decomposition.

Introduction

Honeycombing, a spoilage condition that affects the connective tissue of tuna, appears after the fish have been given a low-pressure steam "precook" to coagulate the flesh protein which facilitates cleaning and cutting before canning (Lassen, 1965; Finch and Courtney, 1976). Honeycombing consists of irregular holes and pitted, sponge-like deposits between the loins (Arnold and Brown, 1978) and sometimes indentations of the loin surface. In extreme cases the connective tissue appears vacuolated and resembles a vacant honeycomb (Hillig, 1956; Otsu, 1957; Lassen, 1965; Tanikawa, 1971; Finch and Courtney, 1976; Frank et al., 1981).

Fresh tunas do not have honeycombing, but those exposed to warm temperatures for extended times can become honeycombed. Tunas that have been cooled properly after catching and refrigerated during storage do not become honeycombed (Otsu, 1957). Because other kinds of deterioration also occur at the same time, honeycombing has been associated with high levels of histamine (Williams, 1954; Finch and Courtney, 1976; Frank et al., 1981), quality deterioration (Hillig, 1956; Lassen, 1965), and scombroid poisoning in commercially canned tuna (Merson et al., 1974).

Screening for honeycombing is a simple way of detecting decomposition in tuna without resorting to time-consuming methods for measuring histamine. For many years the canning industry and regulatory agencies have considered honeycombing to be definite evidence of decomposition in tuna (Hillig, 1956) and acceptable as grounds for rejection of tuna shipments. Rejection of honeycombed tuna at the cleaning stage is considered responsible for the low level of histamine generally observed in commercially canned tuna (Finch and Courtney, 1976). Nevertheless, quantitative measurement of honeycombing has not been used to evaluate tuna decomposition in the canning industry. Since collagen is the major constituent in connective tissue of fish (Love et al., 1982), it is likely that honeycomb formation and collagen breakdown are related. In this investigation we studied the relationship between the amount of honeycombing and collagen breakdown in skipjack tuna, *Katsuwonus pelamis*, decomposed under controlled conditions at several temperatures between 30° and 90°F.

Materials and Methods

Fish

Skipjack tuna, weighing 4-5 pounds each, were caught in the ocean around Oahu, Hawaii, and kept alive until shortly before incubation, as described by Frank et al. (1981).

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Incubation

Forty-one fish were studied and seven were used as untreated, zero-time controls. The remaining 34 tunas were put in separate polyethylene bags containing 4-5 l of filtered fresh seawater and incubated for the desired times at several temperatures: 12 were kept at 30°F, 8 at 40°F, 6 at 50°F, and 8 at 90°F. After incubation, each fish was eviscerated and decapitated, and the two sides were separated. The left side was used to measure honeycombing and the right side to determine collagen content.

Honeycomb Evaluation

The left side of the fish was given a "precook" of 15 minutes at 220°F in a home-style steam pressure cooker and cooled thoroughly. The precook fillet was evaluated by two experienced persons who rated each fish on a five-point scale (Table 1) based on the amount and distribution of honeycombing (Frank et al., 1981). The honeycomb rating for

Table 1.—Scale for evaluating honeycombing in skipjack tuna.

Honeycombing score[1]	Degree of honeycombing[2]
0	None
1	Very slight
2	Slight
3	Moderate
4	Moderate-to-extensive
5	Extensive

[1] Intermediate scores can be assigned where appropriate.
[2] Detailed description of honeycomb appearance for each score is given in Table 1 of Frank et al. (1981).

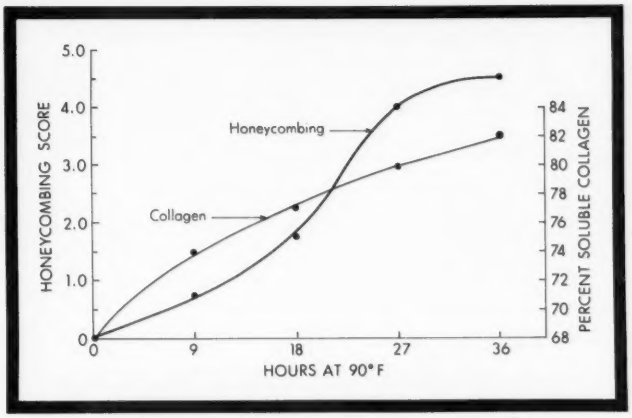

Figure 1.—Honeycomb formation and collagen breakdown during decomposition of skipjack tuna at 90°F. Each data point represents the mean value for two fish incubated for the time shown.

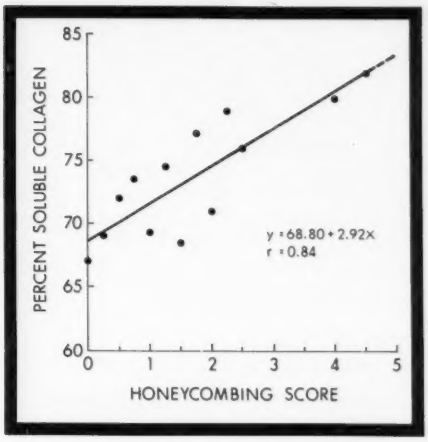

Figure 2.—Relationship between collagen breakdown and honeycomb formation during decomposition of skipjack tuna. Thirty-four fish were incubated for various times at 30°, 40°, 50°, or 90°F. Data points shown are based on results obtained from a minimum of two fish for nearly all cases. The correlation coefficient, r, was highly significant ($p < 0.01$).

each fish was the mean of the scores given by the two judges.

Collagen Determination

Collagen was measured in duplicate 5 g samples from the middle of the uncooked right loin. Each sample was freeze-dried, weighed, extracted with quarter-strength Ringer's solution, and centrifuged to separate the soluble and insoluble collagen fractions (Hill, 1966). Each fraction was hydrolyzed with 6N HCl for 3 hours at 212°F (Thompson and Thompson, 1968), decolorized with activated carbon (Sekoguchi et al., 1978), and its collagen estimated by the method of Woessner (1961) based on the amount of hydroxyproline present. The hydroxyproline portion of skipjack tuna collagen was measured in the insoluble fraction obtained from 140 g of fresh loin tissue by the procedure of Thompson and Thompson (1968). Percent soluble collagen was calculated from the total of soluble and insoluble collagen fractions obtained from each fish.

Statistical Analysis

The correlation between honeycombing score and percent soluble collagen was assessed by linear regression analysis on a Texas Instruments[1] TI-55 programmable calculator. The confidence interval for the slope of the regression line was determined with a t-test (Goldstein, 1964).

Results and Discussion

Collagen in Fresh Skipjack Tuna

Insoluble collagen contained 7.7 percent hydroxyproline; consequently, in the calculations used in this study, 1 mg of hydroxyproline was equivalent to 13 mg of collagen. Samples from loin and belly flap tissue of fresh fish had 68 percent soluble collagen, while the dark, so-called "blood meat" had 75 percent. Loin tissue had 4.34 mg of collagen per g wet weight and 72 percent moisture.

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Honeycomb Formation and Collagen Breakdown

Previously we reported that the optimum temperature for honeycombing in skipjack tuna was about 90°F (Frank et al., 1981). Figure 1 shows that during decomposition of skipjack tuna at 90°F, honeycombing was nearly complete after 36 hours, and soluble collagen increased from 68 to 82 percent. At this stage the fish had deteriorated markedly, and the histamine content was 616 mg per 100 g.

Figure 2 shows the relationship between honeycombing and collagen solubilization during decomposition of skipjack tuna. For every increase of a single unit in honeycombing score, there was a corresponding increase of about 3 percent in collagen solubilized. Thus, honeycombing scores of 1, 2, 3, 4, and 5 corresponded to soluble collagen percentages of 68.6, 71.7, 74.7, 77.6, and 83.7, respectively (Fig. 2).

Further studies are needed to determine the cause of honeycombing in tuna. Solubilization of connective tissue collagen during decomposition may have resulted from collagen melting at elevated temperatures (Stryter, 1975) or from enzymatic activity originating in tuna lysosomes. Wu et al. (1981) reported that lysosomal glucosidases stimulated collagen breakdown in bovine connective tissue during the postmortem ageing process.

Significance of Results

This study shows that a numerical honeycombing scale described earlier (Frank et al., 1981) is correlated with the solubilization of collagen during decomposition of skipjack tuna. These observations suggest that a scale based on the breakdown of connective tissue could be used to measure quality loss. Furthermore, honeycombing appears to be more sensitive than histamine content as a criterion for spoilage in tuna. We have observed that decomposed skipjack tuna with honeycombing scores of about 1.5 invariably contained < 5 mg of histamine per 100 g. We believe that a honeycombing score of 1.5 (corresponding to 73.2 percent soluble collagen) could be employed as a decomposition threshold for skipjack tuna, and that fish with scores exceeding 1.5 can be considered spoiled and discarded. Decomposition thresholds for other types of tuna would require honeycombing studies similar to those reported here for skipjack tuna.

Acknowledgments

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Suitability of Red Hake, *Urophycis chuss*, and Silver Hake, *Merluccius bilinearis*, for Processing Into Surimi

TYRE C. LANIER

Introduction

This report summarizes published and recently obtained information on the suitability of red hake, *Urophycis chuss*, and silver hake, *Merluccius bilinearis*, for the production of surimi. Surimi is a stabilized, frozen, intermediate product prepared by freshwater leaching of mechanically deboned fish muscle (Suzuki, 1981). This yields a bland, light-colored, and highly functional food product which is widely used to make analog seafood products resembling crab meat, scallops, shrimp, etc. (Lanier, 1981, 1983).

Gadoid species in general (and red hake in particular) possess an enzyme-substrate system, trimethylamine oxidase:trimethylamine (TMAOase: TMAO) which can generate formaldehyde during frozen storage (Dingle et al., 1977; Castell et al., 1972). This causes extensive denaturation of the muscle proteins and results in rubbery texture of fillets or minces during frozen storage (Castell et al., 1973; Gill et al., 1979). Holmquist (1982) demonstrated that the combination of water washing of comminuted red hake flesh, which apparently removes much of the enzyme, TMAOase, its cofactor, and/or its substrate TMAO, and the addition of sucrose and sorbitol, which retards freeze denaturation of proteins, yields a product with excellent gel-forming ability even after extended frozen storage. Fillets and mince deteriorated rapidly in frozen storage, exhibiting acceptable gel-forming ability for only 1.5 weeks. Both water-washing and the incorporation of sucrose and sorbitol are key steps in the commercial production of surimi (Suzuki, 1981).

An estimated 75,000 metric tons of silver hake and 40,000 metric tons of red hake remain unfished each year due to lack of markets (USDC, 1983). In light of the encouraging results of Holmquist (1982), which suggested that new markets might be found for this resource in the form of surimi, the New England Fisheries Development Foundation initiated a series of laboratory and commercial surimi processing tests of both species in cooperation with the North Carolina State University/North Carolina Sea Grant and the Gulf and South Atlantic Fisheries Development Foundation. Red and silver hake were each evaluated twice in laboratory trials and once in a commercial trial for their suitability in producing a surimi product having good gel-forming ability.

Materials and Methods

Laboratory Trials

Two laboratory trials for each species were conducted in the pilot plant facilities of the North Carolina State University Seafood Laboratory in Morehead City; one preceded the commercial processing trial and the other followed the commercial trial. In the first, conducted during March 1982, fish of both species were simultaneously air-shipped in ice, in the round, from Pt. Judith, R.I., to near Morehead City, N.C. The fish were about 2-3 days post-harvest upon arrival, and appeared in reasonably good condition except for some deterioration of the belly flaps. They were immediately headed and gutted and divided into two lots. The first lot was immediately deboned and processed into surimi, without prior removal of the belly flaps. Belly flaps were removed from the second lot in anticipation of their contribution to accelerated spoilage, and the fish were stored an additional 3 days in ice before processing.

In the second laboratory trial, the fish were much fresher, being obtained by air shipment within 1 day of harvest. The two species were tested separately, red hake in July and silver hake in October 1982. Half of the lot of each species had been headed and gutted and well cleaned inside prior to shipping, while the remainder were shipped whole. Fish from each were either immediately deboned and processed, or stored in ice for up to 8 days before processing. Storage of whole fish resulted in eventual deterioration of the belly area, especially in the red hake. Therefore, the napes were removed before processing from the red hake which had been stored whole, but were not removed from the silver hake. The headed and gutted fish showed no deterioration of the belly area, and the napes were left on the dressed fish of both species for processing.

The processing procedure for all

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laboratory trials consisted of the following steps. Headed and gutted fish were deboned using a Yanagiya[1] "mini" model drum-type deboner with drum screen orifices 3 mm in diameter. The mince was washed three times, each time in a quantity of ice water three times that of the initial meat weight. The slurry was dewatered following each wash by pouring through a nylon mesh bag and squeezing by hand. Salt (NaCl) was added to the final wash to a 0.15 percent concentration which facilitated dewatering. The final dewatering was accomplished by centrifugation of the mesh bag of mince in a Bock laundry-type centrifuge (Model 10XC, Bock Manufacturing Co., Toledo, Ohio) for about 15 minutes in a 2°C cold room. The final moisture content of this dewatered mince was about 80 percent. Lacking a strainer, the washed mince was directly chopped in a silent cutter (Hobart Model #84142) with a combination of 4 percent sucrose and 4 percent sorbitol added to protect the proteins during frozen storage. The temperature of the mince was maintained below 10°C throughout processing. The surimi thus produced was vacuum packaged in bags of low oxygen permeability, frozen, and held at −20°C until determination of the gel-forming ability could be made (within 1 month).

Commercial Processing Plant Trial

About 900 kg each of red and silver hake were shipped in the round in ice by truck from Pt. Judith, R.I., to Bayou La Batre, Ala., during April 1982. Unfortunately, the fish were received in relatively poor condition due to a combination of factors: The fish had been harvested during heavy feeding on American sand lance, *Ammodytes americanus*, and were quite heavy with roe. Both conditions are commonly thought to contribute to rapid quality deterioration in the fish, particularly by promoting "belly burst" whereby stomach enzymes disintegrate the belly tissue and are released into the fish mass. This condition was observed in many of the fish of both species. Delay in shipping also occurred due to truck malfunctions causing the fish to be held in the round for 3 days prior to processing.

These fish were headed and gutted mechanically on Lapine equipment and the belly flaps were removed. The cleaned fish were washed briefly in a rotary washer and deboned with a Bibun type SDX18 deboner having 3 mm drum orifices. The mince was washed three times, each time with a quantity of cold (less than 5°C) water about three times that of the initial fish weight. Washing was conducted in large stainless steel vats (about 450 kg capacity) by gently stirring the water-mince mixture for 1 minute with a paddle, before allowing the meat to settle for 3 minutes and then dewatering. Dewatering was accomplished by gradually lowering a telescoping drain in the middle of the vat, resulting in removal of only about 75 percent of the added water between washes. Salt (NaCl) at 0.1 percent was added to the final wash to facilitate dewatering of the mince. The slurry from the last wash was passed through a rotating screen drum and finally pressed in a screw press to express excess water. The washed, dewatered mince was then strained in a Bibun type SUM 420 strainer having 1.2 mm orifices to remove remaining bones, scales, and other particulates. Sugar (sucrose) and sorbitol were each added at 4 percent in dry form and thoroughly mixed by comminution in a silent cutter for 1-2 minutes. The surimi was extruded into metal pans lined with plastic bags, each holding about 10 kg, and blast frozen at −20°C. The temperature of the mince and surimi was maintained below 12°C throughout processing and prior to freezing.

Evaluation of Gel-Forming Ability

Gel-forming ability was evaluated by first preparing heat-induced protein gels under standardized conditions, followed by objective (mechanical) measurement of the textural attributes of these gels (Lanier et al., 1982). The procedure used was similar in its approach to that used by the Japanese industry, but different in the methods employed to prepare the gels and measure the textural properties.

Gels were prepared by chopping tempered (about −5°C) surimi with 2 percent salt and ice to achieve a 5:1 moisture:protein ratio. This batter was chopped in a special laboratory vacuum cutter (Lanier et al., 1982) to an end-point temperature of 5°C and transferred to a plastic bag which was vacuum sealed to remove air pockets. The bag was slit at the corner and placed in a sausage stuffer where the cold batter was extruded, without air pockets, into stainless steel tubes (1.25 cm I.D. by 15 cm long) sealed at one end by a stopper and on the other by a threaded brass cap. The tubes were processed in a water bath by one of three schedules:

1) 40°C (104°F) for 30 minutes, followed by a 10-minute cook at 90°C (194°F). This process reveals the ability of the protein to "set" into an elastic gel at low temperatures (Lanier et al., 1982) and can reveal the presence of low-temperature protein-degrading enzymes.

2) 60°C (140°F) for 30 minutes. Marked textural degradation of gels at this temperature is indicative of the presence of so-called "alkaline protease" enzymes (Su et al., 1981; Lanier et al., 1981; Lin and Lanier, 1980).

3) 90°C (194°F) for 10 minutes. This rapidly cooks the batter without the influence of low-temperature setting or protease activity.

The tubes were immediately cooled in ice water after processing. The gels were removed with a Teflon plunger and stored in plastic bags under refrigeration (2°C) before evaluation of the gel texture (within 24 hours).

The texture of each gel was evaluated using a two-bite compression test (texture profile test, Bourne, 1968) between two parallel plates on an Instron Universal Testing Machine. Samples 2.54 cm in length were subjected to a cross-head speed of 100 mm/minute and twice compressed radially to 74 percent of their original thickness. "Hardness" of the samples is defined as the maximum force attained on the first bite divided by the sample weight, and is a measure of the toughness of the samples. "Cohe-

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA, or the North Carolina Agricultural Research Service.

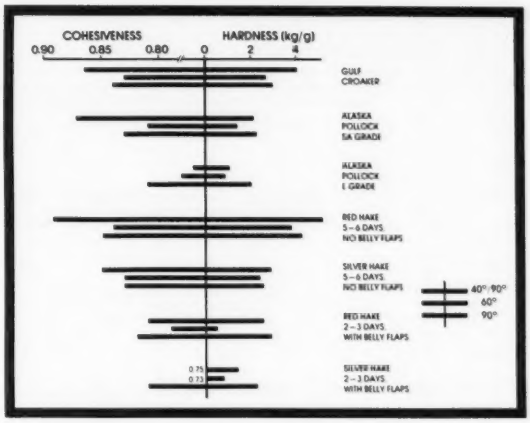

Figure 1.—Instron texture profile values (cohesiveness, hardness) of gels prepared from surimi processed in initial laboratory trial from red hake and silver hake stored 2-3 or 5-6 days in ice, processed with or without belly flaps, and from commercially obtained surimi samples. Process temperatures for gels: 40°/90°C = 40°C incubation for 30 minutes + 90°C incubation for 10 minutes; 60°C = 60°C incubation for 30 minutes; 90°C = 90°C incubation for 10 minutes.

siveness" is defined as the ratio of peak force of the second bite to the peak force of the first bite, and is an indication of the degree of structural integrity retained by the sample after being compressed one time. Hardness and cohesiveness values have been directly related to the "gel strength" and "folding test" values obtained by traditional Japanese methods in this laboratory (unpubl.) and by other workers (Toda et al., 1971).

For comparative purposes, Alaska L (land processed-lower grade) and SA (highest grade) pollock, *Theragra chalcogramma*, (Taiyo Fisheries) and top grade Atlantic croaker, *Micropogonias undulatus*, surimi (Nichibei Fisheries, Inc.) were evaluated for gel-forming ability under identical conditions.

Results and Discussion

The gel-forming abilities, as evidenced by the texture profile values obtained on heat-processed gels, of red and silver hake samples in comparison with pollock and croaker surimi are given in Figure 1. Fish of both species processed with belly flaps on yielded a much poorer gelling product than fish from which the napes were removed. Comparison of the gel-forming ability of the samples without belly flaps with that of commercial high-grade surimi showed that the red hake surimi had much better gelling properties than any of the commercial samples, while the silver hake surimi possessed about the same gelling properties as the high-grade commercial samples.

Surimi prepared from both hake species processed with belly flaps on had poor gelling properties similar to the L-grade Alaska pollock surimi. Textural degradation at 60°C was evident and likely attributable to the presence of heat-stable proteases which may have leached into the belly region from organ tissues (Su et al., 1981). The poor performance of these samples when processed by a 40°/90°C or 90°C schedule seems due to the inclusion of the belly tissue. This tissue likely had very poor gel-forming properties and may have actually inhibited gel formation of the more functional muscle proteins. Any protease contributed by inclusion of the belly flaps should have had no effect on the 90°C processed samples. Heat transfer was rapid in the sample tubes used such that protease would have quickly been inactivated.

Surimi prepared from both species of hake processed without belly flaps was held in frozen storage at −20°C for 3 months and the gel-forming ability evaluated as before. The results (Fig. 2) reveal that neither surimi significantly changed in gel-forming properties over this storage period. While 3 months is not an especially long storage period for surimi, changes in texture-forming properties of red hake minces have been known to occur rapidly over much shorter storage periods (Dingle et al., 1977; Holmquist, 1982). Our data thus confirm the Holmquist (1982) report that surimi produced from red hake is more stable in frozen storage than unrefined mince.

Commercial Processing Plant Trial

The encouraging results with respect to the high gel-forming ability obtained in the laboratory-processed surimi from both red and silver hake led to a processing trial in a commercial surimi plant.

However, problems were encountered during procurement of fish for this trial which resulted in poor quality fish for processing. The gel-forming ability of the surimi produced was therefore very poor (Fig. 3). The gel-forming ability was slightly less than that of surimi processed in the laboratory from fish with belly flaps on (Fig. 1). The low values for gel-forming ability, although disappointing, do accentuate the need to use high-quality fish of these species for processing into surimi, even for fish from which the napes are removed prior to deboning (as was done in this trial for both species).

The color of the surimi produced in this trial, although not precisely measured, was subjectively judged to be equal or greater in lightness to that of the high-grade commercial samples. The processing equipment used was therefore deemed adequate in its ability to remove the dark belly lining of the hake which might otherwise detract from the appearance of the surimi.

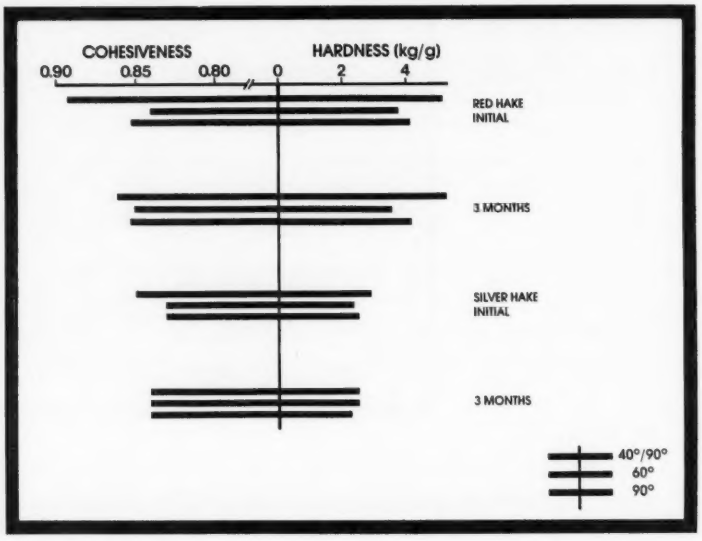

Figure 2.—Instron texture profile values (cohesiveness, hardness) of gels prepared from fresh (initial) and frozen (3 months) samples of red hake and silver hake surimi processed in the initial laboratory trials; gel process temperature codes are same as Figure 1.

Final Laboratory Trials

Final laboratory trials of red and silver hake were conducted to determine more accurately the effect of holding method (whole or eviscerated) and time in ice on the gelling quality of the processed surimi.

The results of this trial for red hake are shown in Figure 4. Surimi prepared from fish stored whole evidently possessed a high content of heat-stable protease, as evidenced by the poor texture of gels prepared at 60°C. However, the texture of gels prepared at 90°C or 40°/90°C was slightly better for surimi prepared from fish stored whole than for that processed from the fish stored dressed. This may be attributed to the absence of the napes in the processing of the fish stored whole. Hardness values decreased somewhat with time of holding while cohesiveness values remained nearly constant.

The results of the final laboratory processing trial for silver hake are shown in Figure 5. The fish stored whole for 8 days were judged unfit for processing; thus, no data is included for this treatment. Again, fish stored whole apparently possessed a higher content of

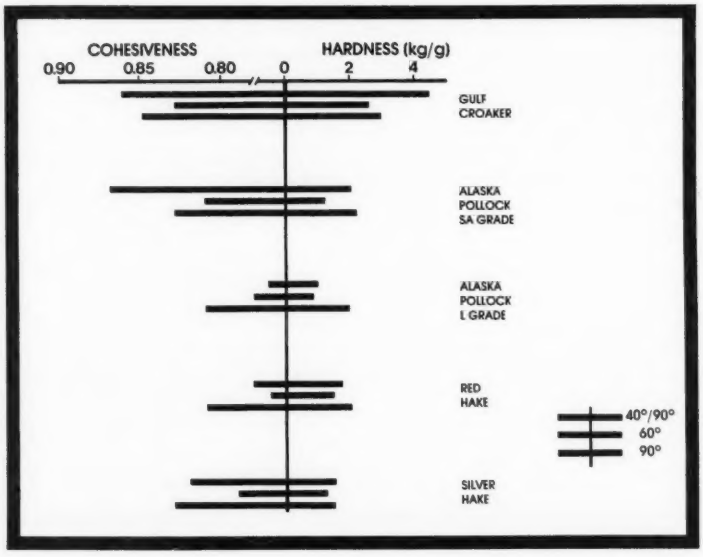

Figure 3.—Instron texture profile values (cohesiveness, hardness) of gels prepared from surimi processed in commercial trial of red and silver hake and from commercially obtained surimi samples; gel process temperature codes are same as Figure 1.

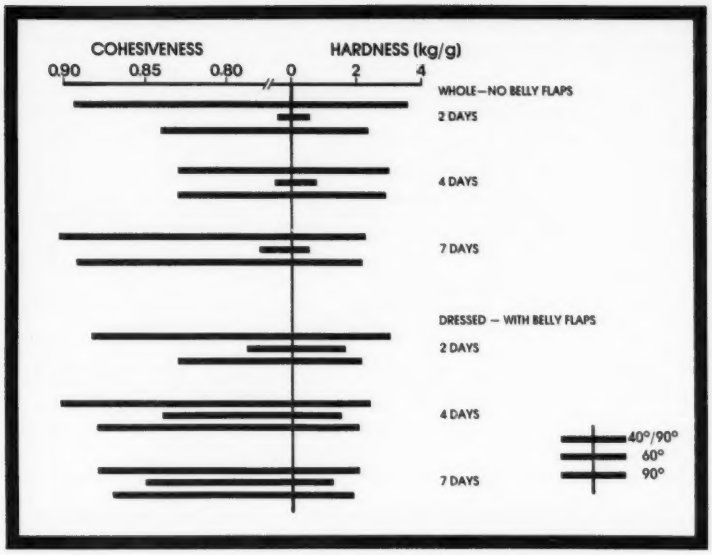

Figure 4.—Instron texture profile values (cohesiveness, hardness) of gels prepared from surimi processed from red hake stored whole (processed without belly flaps) or dressed (processed with belly flaps) in ice for 2, 4, or 7 days; gel process temperature codes are same as Figure 1.

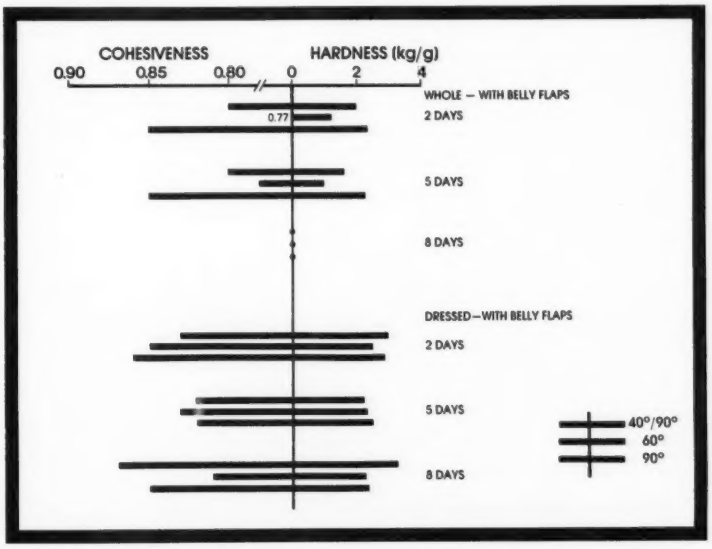

Figure 5.—Instron texture profile values (cohesiveness, hardness) of gels prepared from surimi processed from silver hake stored whole or dressed (both processed with belly flaps) in ice for 2, 5, or 8 days; gel process temperature codes are same as Figure 1.

heat-stable protease, as evidenced by the poorer texture of the gels prepared at 60°C. Contrary to the results for red hake (Fig. 4), the dressed fish produced surimi having higher gel-forming ability in most cases. The difference may be explained by the inclusion of the belly flaps in the processing of both treatments in the test of silver hake, whereas the belly flaps were removed from the whole-stored fish in the test of red hake. While the 90°C processing temperature resulted in similar texture values for gels prepared from fish stored both whole and dressed, the 40°/90°C process yielded much lower values for the whole-stored fish. This suggests that either the belly flap tissue contained protease that was active during the 40°C precook, or that deterioration of the belly flaps during storage resulted in a material which, when included in the processing of the surimi, interfered with the 40°C "setting" ability of the tissue.

From these data and those of the first laboratory trial, it must be concluded that removal of the napes prior to deboning and processing would be beneficial to the gel-forming ability of the resultant surimi, regardless of whether the fish had been dressed immediately upon harvest or later at the time of processing. The (presumed) elevated protease levels in surimi prepared from whole-stored fish are undesirable and could lead to serious textural problems in products prepared from such surimi if the thermal process temperature is not strictly controlled. Therefore, rapid gutting of fish is advisable, particularly when the fish have been feeding heavily as were the fish used for the commercial trial. While no objective measurements were made regarding the quality of fish at any day of processing, subjectively it was determined that gutting the fish enhanced overall fish quality during iced storage in agreement with other published studies (Townley and Lanier, 1981). This factor could influence organoleptic attributes of the surimi other than its gel-forming ability.

Conclusion

These results suggest that red and silver hake, and particularly red hake, have excellent potential as raw material

for surimi production when high-quality fish are used as the starting material. Besides producing a surimi of exceptional quality, the red hake are in good supply, have limited other food uses, and are therefore a low-cost material. As the consumption of restructured seafoods increases in this country, a rising demand for surimi will offer potential for development of underutilized fish species as a food resource. Such development of the hake resource would extend our domestic fishing industry and offset the need to import Japanese-processed products.

Acknowledgments

The author would like to acknowledge the New England Fisheries Development Foundation, Gulf and South Atlantic Fisheries Development Foundation, Nichibei Fisheries, Inc., and North Carolina Sea Grant Program for their partial financial support of this research. Additionally, the fine technical assistance of Susan Lovelace and Barbara Barbour is gratefully recognized.

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Investment in Gulf of Mexico Shrimp Vessels, 1965-77

ERNEST O. TETTEY and WADE L. GRIFFIN

Introduction

Major capital inputs in the Gulf of Mexico shrimp fishery are vessels and gear. Since the early 1900's, equipment and techniques used in shrimp fishing have changed dramatically. The early vessels were constructed of wood and used drag seines, cast nets, and traps to harvest shrimp. Today's shrimp vessels, built of wood, steel, or fiberglass, are larger and equipped with sophisticated trawling gear and electronics. In addition, the total number of Gulf shrimp vessels has steadily increased (Prochaska and Cato, 1981).

Fishermen, operating in an open-access common-property resource, will expand effort (usually by increasing the number of vessels) as long as excess profits to individual firms exist (Crutchfield and Zellner, 1962; Gordon, 1954; Scott, 1955; Smith, 1969; Turvey, 1964). This increased effort by individual fishermen imposes extra cost burdens on other fishermen and usually gives rise to overcapitalization[1] from an economic standpoint.

This study examines implications of investment patterns in the Gulf shrimp fishery. Historical trends in capital stock (in dollars) of vessels are estimated for 1965-77 for different types of vessels for use with landings and sales data. Specifically, annual trends in total and per-vessel shrimp landings and sales are examined. Shrimp landings and sales per dollar of investment in fishing vessels are evaluated.

[1]The fishing effort or number of firms beyond that necessary to harvest the maximum economic yield.

Table 1.—Total number of shrimp vessels in the Gulf of Mexico by vessel construction type[1].

	Vessel construction						
	Wood		Steel		Fiberglass		
Year	No.	%	No.	%	No.	%	Total
1965	2,473	93.4	175	6.6			2,648
1966	2,576	90.7	265	9.3			2,841
1967	2,618	88.4	345	11.6			2,963
1968	2,683	83.1	544	16.9			3,227
1969	2,803	81.5	631	18.4	4	0.1	3,438
1970	2,650	80.4	639	19.4	5	0.2	3,294
1971	2,594	76.3	788	23.2	17	0.5	3,399
1972	2,597	74.9	851	24.6	17	0.5	3,465
1973	2,675	77.6	758	22.0	16	0.4	3,449
1974	2,582	69.9	1,074	29.1	37	1.0	3,693
1975	2,637	71.5	1,017	27.6	36	1.0	3,690
1976	2,771	69.0	1,198	29.8	45	1.1	4,014
1977	2,935	67.5	1,356	31.2	55	1.3	4,346

[1]Source: NMFS unpublished operating units files for shrimp vessels, 1965-77.

Trends in Investments

Characteristics of the Gulf Shrimp Fleet

Historically, wooden vessels dominated the Gulf shrimp fleet (Table 1). Of the 2,648 vessels reported fishing in the Gulf area in 1965, 93.3 percent were wood, and the rest were steel. There has since been a steady substitution of steel and fiberglass vessels for wooden ones. Steel vessels accounted for 13.2 percent of the Gulf fleet in 1977, while the percentage of wooden vessels dropped to 67.5 percent.

Four fiberglass vessels joined the fleet in 1969, and in 1977 there were 55 fiberglass vessels representing 1.3 percent of the Gulf fleet. In the 1970's, a few vessels built of concrete, aluminum, and metallic alloys were introduced, but they have made no significant change in the Gulf shrimp fleet. This study has thus been limited to the evaluation of wood, steel, and fiberglass vessels[2].

The average length of vessels registered with the U.S. Coast Guard increased from 48 feet in 1965 to 59 feet in 1977 (Tables 2 and 3). In 1965, only 14.3 percent of the fleet was less than 5 years old, but the percentage increased to 33.7 by 1977. The average Gulf shrimp vessel became larger and newer between 1965 and 1977.

Estimated Investment

The capital stock in dollars of vessels fishing for shrimp in the Gulf of Mexico was estimated as follows:

$$KT_t = \sum_l \sum_c \sum_l P_{lct} N_{lct}$$

where KT_t = total real capital stock of vessels built in year t;
P_{lct} = cost of a vessel of length l, constructed of material c, and built in year t;
N_{lct} = number of vessels of length l, constructed of material c, and built in year t;

[2]Vessels are fishing craft of 5 net tons or more in cubic capacity. They are either enrolled or documented by the U.S. Coast Guard and have an official number assigned by that agency. Boats have a capacity of less than 5 net tons. There are more boats than vessels fishing for shrimp in the Gulf of Mexico, but they account for less of the catch, about 25 percent in 1976.

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Table 2.—Number of shrimp fishing vessels by length and construction year in the Gulf of Mexico shrimp fishery, 1965[1].

Year of construction	Length (feet)														
	0-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	Total
1910	6	7	3	6	2	2	0	0	0	0	0	0	0	0	26
1920	6	6	2	0	0	1	0	0	0	0	0	0	0	0	15
1930	21	23	13	5	2	1	0	0	1	0	0	0	0	0	66
1940	20	59	49	49	8	2	3	0	0	0	0	0	0	0	190
1950	83	85	130	149	150	51	29	3	2	1	0	0	0	0	683
1960	109	64	81	182	208	244	275	20	4	1	0	0	0	0	1,188
1965	54	57	43	32	36	36	160	60	1	0	1	0	0	0	480
Total	299	301	321	423	406	337	467	83	8	2	1	0	0	0	2,648

[1]Source: NMFS unpublished operating units files for shrimp vessels, 1965-77.

Table 3.—Number of shrimp fishing vessels by length and construction year in the Gulf of Mexico shrimp fishery, 1977[1].

Year of construction	Length (feet)														
	0-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	Total
1910	1	1	2	5	0	2	0	0	0	0	0	0	0	0	11
1920	3	5	2	1	0	1	0	0	0	0	0	0	0	0	12
1930	16	16	11	4	1	0	0	0	0	0	0	0	0	0	48
1940	11	46	37	34	6	2	1	0	1	0	0	0	0	0	138
1950	50	66	71	91	95	35	15	3	2	0	0	0	0	0	428
1960	50	46	54	101	110	103	131	7	2	1	0	0	0	0	605
1965	55	44	46	18	23	22	92	33	3	0	0	0	0	0	336
1966	13	15	12	9	14	12	30	43	20	0	1	0	0	0	169
1967	17	15	14	2	5	11	31	72	28	5	0	0	0	0	200
1968	25	19	10	7	6	12	34	75	40	9	1	1	0	0	239
1969	16	16	15	1	6	7	30	58	18	9	0	0	0	0	176
1970	14	12	15	7	3	7	17	53	5	6	0	0	0	0	139
1971	15	16	19	9	5	11	28	49	12	8	0	0	0	0	172
1972	18	16	14	8	8	12	35	66	20	9	0	0	0	0	206
1973	11	13	9	9	11	14	46	67	26	0	1	0	0	0	207
1974	16	10	11	6	11	19	49	80	31	6	2	0	1	0	242
1975	18	13	7	8	8	12	58	84	55	18	2	0	0	0	283
1976	9	10	26	20	17	5	9	56	155	67	32	1	0	0	407
1977	14	14	30	32	14	18	8	62	56	56	22	1	0	1	328
Total	372	393	405	372	343	305	614	808	474	194	61	3	1	1	4,346

[1]Source: NMFS unpublished operating units files for shrimp vessels, 1965-77.

l = length of vessel (0-35 feet, 36-40 feet, ... 96-100 feet);
c = material of which vessel is constructed (wood, steel, fiberglass), and
t = year in which vessel is built (1900-10, 1911-20, ... 1977).

Vessel costs, expressed in 1977 dollars, were estimated from cost data provided by vessel builders and owners. Griffin et al. (1978) have shown that vessel length, material of construction, and year of purchase were the most significant factors determining the cost of a vessel, and the relationship is of a log linear form

$$P_{lct} = a(L)^b\, e^{d_i c}\, e^{d_j t}$$

where a and b are estimated coefficients and d_i and d_j are estimated coefficients of dummy variables. The productive decay pattern which underlines capacity depreciation in vessels was ignored in deriving the real capital stock due to insufficient data.

The resulting estimated real capital stock (in 1977 dollars) of fishing vessels almost tripled from 1965 to 1977 (Table 4), although fluctuation occurred. The capital stock of wooden vessels increased moderately (43 percent) over the study period from $116 million in 1965 to $167 million in 1977. Steel vessels increased 1,200 percent from $15 million in 1965 to $195 million in 1977.

Table 4.—Real capital stock of Gulf of Mexico shrimp vessels by vessel construction type (1977 dollars).

Year	Vessel stock (million dollars)			
	Wood	Steel	Fiberglass	Total
1965	116.7	15.0		131.7
1966	123.6	23.9		147.5
1967	127.3	32.4		159.7
1968	131.8	63.3		195.1
1969	140.1	76.4	0.4	216.9
1970	133.6	67.5	0.4	201.5
1971	135.9	94.3	1.5	231.7
1972	136.7	104.8	1.8	243.3
1973	141.7	92.7	1.6	236.0
1974	140.2	142.9	3.6	286.7
1975	141.7	123.1	3.7	268.5
1976	153.0	164.0	4.7	321.7
1977	167.0	195.2	5.8	368.0

Source: NMFS unpublished operating units files for shrimp vessels, 1965-77.

During the 1970's, steel vessels began to exceed wooden vessels in real capital stock, though not in numbers, landings,

or value of landings (Tables 1, 4, 6, and 7). This may be attributed in part to the high costs associated with steel vessels. Fiberglass vessels increased 1,450 percent from $0.4 million in 1969 to $5.8 million in 1977.

Negative real net investment[3] (a decline in real capital stock) was observed in 1970, 1973, and 1975 (Table 5). This follows a decline in vessel stocks as a consequence of poor yields as well as unfavorable economic conditions. Real net investment is highly responsive to certain economic factors facing the Gulf shrimp fishery. National economic downturns occurred in 1970, 1974-75, and 1979-80, reducing the demand and prices for shrimp. Fuel costs have become significant to the shrimp industry, especially when prices jumped in 1973-74 and 1979-80. During the period of this study, returns above cost from shrimping declined from 1973 through the middle of 1975 due to a combination of economic factors, including increased fuel costs, lower shrimp prices during part of the time, and poor landings (Warren and Griffin, 1980). This led to negative real net investment in vessels in 1973 and 1975. Conditions began to improve in the middle of 1975, bringing record real net investments in 1976-77 (Table 5).

Table 5.—Real net investment in Gulf of Mexico shrimp vessels by vessel construction type (1977 dollars).

Year	Real net investment[1] (million dollars)			
	Wood	Steel	Fiberglass	Total
1966	6.9	9.0		15.9
1967	3.7	8.5		12.2
1968	4.5	30.9		35.4
1969	8.9	13.0		21.3
1970	−6.5	−9.0	−0.1	−15.5
1971	2.2	26.9	1.2	29.3
1972	0.8	10.5	0.2	11.5
1973	5.0	−12.2	−0.2	−7.0
1974	−1.6	50.2	2.0	50.8
1975	1.5	−19.8	0.1	−18.2
1976	11.3	40.9	0.9	53.1
1977	14.0	31.2	1.0	46.3

[1]Real net investment is computed as the year-to-year change in real capital stock from Table 4.
Source: NMFS unpublished operating units files for shrimp vessels, 1965-77.

Table 6.—Total shrimp landings from the Gulf of Mexico by vessel construction type.

Year	Landings[1] (million pounds)			
	Wood	Steel	Fiberglass	Total
1965	84.0	13.9		97.9
1966	76.4	12.5		88.9
1967	89.7	20.0		109.7
1968	79.4	22.7		97.6
1969	62.2	27.3	0.1	89.6
1970	64.1	30.7	0.1	94.9
1971	62.4	34.9	0.7	98.0
1972	60.1	41.8	0.7	102.6
1973	50.3	30.0	0.4	80.7
1974	43.1	34.2	1.1	78.4
1975	41.1	30.7	0.8	72.6
1976	55.7	42.5	0.9	99.1
1977	61.6	50.6	1.2	113.4

[1]Landings are determined on head-off basis and exclude catch by boats.
Source: NMFS unpublished Gulf of Mexico shrimp landings data files, 1965-77.

Table 7.—Total shrimp landings value from the Gulf of Mexico by vessel construction type (1977 dollars).

Year	Shrimp value (million dollars)			
	Wood	Steel	Fiberglass	Total
1965	91.9	15.3		107.2
1966	104.6	17.2		121.8
1967	102.5	22.8		125.3
1968	96.9	29.3		126.2
1969	81.6	35.7	0.2	117.5
1970	72.9	34.9	0.2	108.0
1971	87.2	48.8	1.0	137.0
1972	95.6	66.5	1.1	163.2
1973	99.9	59.6	0.8	160.3
1974	61.4	48.8	1.6	111.8
1975	75.3	56.4	1.4	133.1
1976	121.9	93.0	2.0	216.9
1977	111.5	91.6	2.2	205.3

Source: NMFS unpublished Gulf of Mexico shrimp landings data files, 1965-77.

Total Landings, Sales, and Capital Stock

Over the 14-year period, Gulf shrimp landings varied significantly with vessel construction (Table 6). An increase in the total number of vessels employed does not necessarily lead to an increase in the total amount of shrimp caught as indicated in Tables 1 and 6. Specifically, the vessel-to-shrimp landings correlation coefficient (0.54) is unusually low because landings are at or near the maximum sustainable yield. Total Gulf landings appear to have fluctuated about a mean since the mid-1950's when growth subsided (Prochaska and Cato, 1981).

Table 6 shows a general upward trend in shrimp landings from 1965 to 1972 for steel and fiberglass vessels. Considerable fluctuations, however, were observed for both vessel types after 1972. There is a downward trend in shrimp landings from 1965 to 1972, with fluctuation beyond 1972 for wooden vessels. The variability in shrimp landings may be attributed to biological and economic factors and to pushing the fishery to its maximum production capacity. If the shrimp population is low, for example, landings would be less; and if the economy is depressed, shrimpers would shrimp less. Evidently, as the number of vessels increases, reaction to these conditions becomes more diverse causing greater variation in landings.

Steel vessels generally have a larger share of catch relative to the number of vessels than wooden and fiberglass vessels, but the respective shares of catch and catch value are roughly proportional to capital stock. In 1977, steel vessels accounted for only 31 percent of the entire Gulf fleet but represented about 45 percent of the quantity and value of landings and 53 percent of the capital stock (Tables 1, 4, 6, and 7). Wooden vessels constituted 68 percent of the Gulf fleet, accounted for 54 percent of the quantity and value of landings, and had 45 percent of the value of capital stock.

The value of landings increased steadily from $107.2 million in 1965 to $205.3 million in 1977 with much of the recent growth being from real increases in shrimp price (Tables 6 and 7). While the correlation between the number of vessels and catch is low, there is a statistical relationship between fleet expansion and shrimp price (Prochaska and Cato, 1981). It seems unlikely that this relationship will continue because the inflationary trend which began in 1973 affected not only prices received but prices paid by fishermen (Tettey et al., In press). Fuel prices jumped in 1973-74 and again in 1979-80. Apparently, the relationship between shrimp prices and fleet expansion was held during the period for which data were available for this study because there were tremendous increases in total value of catch (in

[3]The NMFS data on vessels represent the number of vessels actually fishing. However, even in "bad years" all vessels fish at least once so they are counted as part of the fleet. Therefore, negative net investment is not occurring because a vessel may remain idle one year and positive net investment is not occurring because they start fishing the next "good year." Rather, negative real net investment is experienced in the current period whenever real capital stock in the previous year exceeds that of the current year. By description, real net investment is $KT_t - KT_{t-1}$.

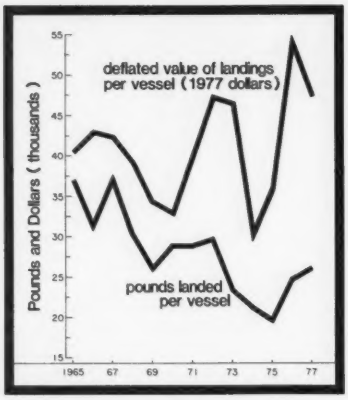

Figure 1. — Shrimp pounds and value landed per vessel in the Gulf of Mexico shrimp fishery, 1965-77.

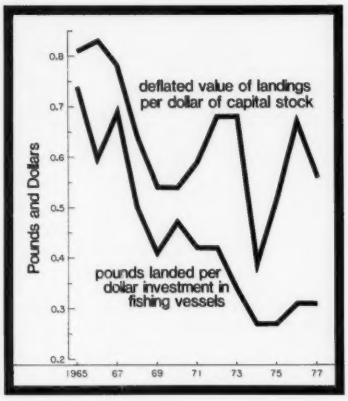

Figure 2. — Shrimp pounds and value landed per capital stock in vessels in the Gulf of Mexico shrimp fishery, 1965-77.

constant 1977 dollars) and capital stock in vessels (in constant 1977 dollars) in 1976 (Tables 4 and 7).

Per Vessel Landings, Sales, and Capital Stock

Figure 1 indicates that the value of shrimp landings per vessel (in 1977 dollars) fluctuated considerably since 1965, with little if any sign of a rising trend. Revenue for shrimp landings per vessel increased only $6,800 over the 12-year period. A low of $30,300 per vessel was recorded in 1974 and a high of $54,000 was recorded in 1976. The trend reflects, largely, the movement of ex-vessel prices for shrimp (deflated to 1977 dollars) over the years.

In contrast, shrimp landings per vessel have trended downward from 36,900 pounds in 1965 to 26,000 pounds in 1977. A high of 37,000 pounds was observed in 1967, and a low of 19,600 pounds was harvested in 1975. The decline in pounds per vessel is inevitable due to a tremendous increase in number of vessels exploiting a given stock of shrimp. Shrimp pounds landed per dollar invested in fishing vessels also declined sharply from 0.75 pounds in 1965 to 0.31 pounds in 1977 (Figure 2). There were some fluctuations in the shrimp landings with a minimum of 0.27 pounds recorded in 1975.

The value of shrimp landings per dollar investment in vessels decreased from $0.81 in 1965 to $0.56 in 1977 (Figure 2). It is evident that capital productivity has generally trended downward in the Gulf shrimp fishery. For every dollar invested in fishing vessels, as much as $0.83 worth of shrimp was landed in 1966 as against $0.39 in 1974. As more vessels enter the fishery, the problems become more pronounced. In response to such a growing disparity between output per vessel and the amount of capital added to the fishery, shrimp fishermen appear to have cut back in fishing days. Landings per fisherman day have increased and the entire labor force in the Gulf shrimp fishery has become more efficient (Miller and Surdi, 1981).

Conclusions

The pounds of shrimp landed per vessel in the Gulf of Mexico decreased sharply over the study period. The estimated real capital stock of vessels (in 1977 dollars) almost tripled during 1965-77 to $368 million, while pounds of shrimp landed per dollar invested in fishing vessels continued to decrease from 0.75 in 1965 to 0.31 in 1977. In 1977 dollars, the value of catch per dollar of investment also fell, dropping from $0.81 in 1965 to $0.56 in 1977.

Apparently, the perceived value of landings per vessel increased on average at a faster rate than production costs per vessel causing excess profit to exist. This created an incentive for investments, although there may be other reasons for stimulating investment. This expansion was interrupted only by poor economic conditions, such as in 1970, and 1973-75. Although data were not available to estimate real capital stock beyond 1977, other information suggests that substantial declines (large negative real investment) occurred in 1979-80.

Acknowledgments

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Characteristics of the Texas Shrimp Fleet, 1979-82

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ABSTRACT—Sound management of the Texas shrimp fishery requires an understanding of the composition of the shrimp fleet and its response to changing economic conditions and regulations. This study utilized Texas Parks and Wildlife Department licensing data to quantitatively describe and evaluate the commercial fleet from 1979 to 1982. Tables representing the number of vessels in the fleet, the license (bay, bait, Gulf) or license combinations that they maintain, the home ports of vessels, and the counties of residence of vessel owners, are presented. Despite yearly fluctuations, the shrimp fleet has been increasing, as have been the purchases of single and multiple licenses. Decreases in the number of vessels in the fleet for any given year resulted primarily from vessels less than 25 feet in length and vessels 55-70 feet in length leaving the fishery. The expansion of the fleet in 1981 and its relationship to 1981 fisheries legislation is discussed.

Introduction

The shrimp fishery is the most valuable commercial fishery in Texas. The fishery is characterized as an open-access common property resource utilized by two user groups, recreational and commercial fishermen. Both groups participate in each of two distinctly different sectors of the fishery, the inshore sector, physically described by bays and inlets, and the offshore, or Gulf sector.

In the inshore sector fishermen harvest small, juvenile brown shrimp, *Penaeus aztecus*, and white shrimp, *P. setiferus*, on a daily basis with vessels ranging in size up to 55 feet. In contrast, the offshore sector supports primarily larger vessels from 55 feet to >70 feet which fish on a trip basis, staying away from port for 2-4 weeks (Maril[1]), and which harvest large, mature brown and white shrimp, although some immature brown, white, and pink shrimp, *P. duorarum*, make up part of their catch (Christmas and Etzold, 1977).

The economic contribution of the total commercial landings in Texas varies greatly from year to year. The variations are, in part, a function of the economic conditions within the fishery, such as fishing costs and price of the catch. The years 1976-78 generally were profitable years for the Texas shrimp fishery (Tettey et al., 1984). However, during 1979 fuel prices nearly doubled from \$1.30/10 l to \$2.20/10 l (Tettey et al., 1984). Total landings decreased but the actual value of the commercial harvest increased[2]. During 1980, fuel prices continued to rise (\$2.50/10 l) and the total value of Texas landings decreased by 8 million dollars. The greatest variation in value of the landings occurred from 1981 to 1982. Within these two years landings and their associated value decreased from a record high (59.5 million pounds, 165 million dollars, 1981) to a record low (26 million pounds, 97 million dollars, 1982) (footnote 1).

Sound management of the Texas shrimp fishery requires an understanding of the complex interplay between user groups and fishing sectors. However, analyses of catch/effort relationships (Christmas and Etzold, 1977), economic costs/returns relationships (Griffin and Nichols, 1976), and bioeconomic interrelationships (Grant and Griffin, 1979) within the fishery have been based on a variety of assumptions about the composition of the commercial shrimp fleet. Few studies have presented empirical descriptions of the shrimp fleet (Warren, 1979; Warren and Bryan, 1981). Our study quantitatively characterizes the Texas shrimp fleet during 1979-82 and evaluates changes in the composition of the fleet in light of recent regulatory measures.

Data Source

The Texas Parks and Wildlife Department (TPWD) commercial license records (1979-82) were the data source for the present study. By law a vessel is required to be licensed for each fishery (bay, bait, Gulf) in which it participates. Since additional information such as vessel length, home port, county, and vessel identification number (U.S. Coast Guard number or TPWD number) must be reported with each license purchased, the Texas Parks and Wildlife license records provide a rich data set from which a description of the fleet can be generated.

The TPWD licensing system describes restrictions regarding where and when commercial and recreational fishermen may fish and the amount they may harvest. Commercial licenses include a commercial bay shrimp license,

[1]Maril, R. 1979. Shrimping in Texas: Social and economic marginality fishing for a luxury commodity. Paper presented to the Association for Humanist Sociology, Johnston, Penn., 42 p.
[2]Unpublished data on file at National Marine Fisheries Service, Galveston, Tex.

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a commercial bait shrimp license, and a commercial Gulf license. Recreational licenses include a sport fishermen license and an individual bait shrimp trawl license. By definition a commercial bay shrimp boat is a registered boat used for taking shrimp for pay or sale from the major bays. A commercial bay boat may catch no more than 300 pounds of any size shrimp per day during the open spring season (15 May through 15 July) and may catch any amount during the open fall season (15 August through 15 December).

A commercial bait boat is a registered boat used in inside or bay waters for taking bait shrimp for sale or pay. Prior to 1981 bait boats were required to have adequate live holding facilities for shrimp and could catch no more than 150 pounds of any size shrimp per day during the bait shrimp season (open throughout the year except at night during the open fall season). At least 50 percent of the onboard catch had to be kept alive. As of August 1981 the harvest limit for bait shrimp increased to 200 pounds per day with no requirement to maintain 50 percent of the shrimp alive (from 15 August through October).

A commercial Gulf shrimp boat is a registered boat used for catching shrimp for sale or pay from the Gulf or "outside waters." Outside waters are defined in part as that portion of the Gulf of Mexico extending from the shoreline seaward and within the jurisdiction of the State of Texas (Christmas and Etzold, 1977).

Two recreational licenses, an individual bait-shrimp trawl license and a sport fishing license, are available to persons shrimping for personal use only. However, since the legal catch limits for personal use (no more than 4 quarts per boat during any closed season in inside waters, no more than 100 pounds legal size whole shrimp per day from major bays during open fall season and from outside waters during open Gulf season, no more than 15 pounds from major bays during open spring season) are smaller than those for commercial licenses, many recreational and part-time fishermen purchase commercial licenses (Christmas and Etzold, 1977).

Licensing data were provided by TPWD on a computerized tape containing files by license year. For example, license year 1980 was from 1 September 1979 through 31 August 1980. Since any given vessel can hold one or more licenses (such as a bay/bait license combination) a number of individual vessels had more than one record entered, leading to duplication of vessels. To eliminate this duplication, data within license years were sorted by vessel number, providing a listing of current licenses held by each vessel. From this data base further data sets were generated with compilations by vessel size, home port, and county.

Vessels were aggregated into the five size classes used by Warren and Bryan (1981): 25 feet and under; over 25 through 40 feet; over 40 through 55 feet; over 55 through 70 feet; and over 70 feet. The boundaries of these five classes were based on the observations that most part-time, occasional, and recreational fishermen use small boats less than 25 feet (Warren and Bryan, 1981) although some boats used are less than 40 feet (Gulf of Mexico Fishery Management Council, 1981), that most commercial bay and bait shrimpers use vessels between 25 and 55 feet although these size classes include a number of Gulf vessels, and that most Gulf vessels are longer than 55 feet.

Table 1.—Number of licensed vessels in the Texas shrimp fleet each year from 1975 to 1982 from TPWD license records. Data from 1975 to 1978 taken from those presented by Warren (1979). Data for 1979 differs from Warren and Bryan (1980). At the time of their study, 1979 data files did not include all entries.

Size class (length in feet)	Number of licensed vessels							
	1975	1976	1977	1978	1979	1980	1981	1982
≤25	2,367	2,136	2,413	2,659	3,543	3,214	3,707	3,327
25-40	1,158	1,138	1,127	1,147	1,360	1,453	1,637	1,619
40-55	379	380	359	371	413	437	536	491
55-70	1,013	996	1,012	1,078	1,197	1,099	1,268	1,106
70<	295	256	289	298	386	395	442	372
Total	5,212	4,906	5,200	5,553	6,899	6,598	7,590	6,915

Fleet Characteristics

Number of Vessels

A comparison of the number of commercially licensed vessels, by size class, that participated in the fishery each year from 1975 to 1982 indicates that while the fleet expanded and contracted on a yearly basis the total number of vessels in the fishery increased in a generally linear fashion (Table 1). The yearly variation of the total number of vessels can be attributed primarily to the relatively large variation of smaller vessels that entered or left the fishery. For example, during 1981 a net of 992 vessels entered the fishery, marking 1981 as a record year in terms of vessel participation in the commercial fleet. Smaller vessels (<25 feet in length) accounted for 50 percent of the increase. From 1981 to 1982 there was a decrease in vessel numbers in all size classes; smaller vessels accounted for 56 percent of the overall decrease.

The proportional size class composition of the shrimp fleet remained fairly constant from 1975 through 1982. Vessels less than 25 feet were by far the most numerous licensed vessel. In contrast, the largest (>70 feet) vessels represented the smallest proportion of the fleet.

Number of Licenses

In terms of total number of licenses purchased, 1981 was a record year, corresponding to an overall increase in vessels entering the fishery during that year (Table 2). Of the additional 1,566 bay, bait, and Gulf licenses purchased, 60 percent were bay licenses, representing the single largest annual increase (24 percent) in bay licenses. In general, however, the number of bay and Gulf license purchases fluctuated on a yearly basis. Note, for example, that despite the 1981 increases the 1982 total number of Gulf and bay licenses did not differ significantly from 1979 levels. In contrast, the number of bait licenses steadily increased despite overall decreases in (total) license purchases in 1980 and 1982.

Table 2.—Total number of bay, bait, and Gulf licenses purchased each year from 1979 to 1982 from TPWD license records. Parenthetical entries represent the net change in the number of licenses purchased between the indicated year and the previous year.

Type of license	Total licenses purchased							
	1979	1980		1981		1982	
Bay	4,260	3,960	(−300)	4,893	(+933)	4,277	(−616)
Bait	1,766	1,979	(+213)	2,185	(+206)	2,207	(+22)
Gulf	3,300	3,245	(−55)	3,672	(+427)	3,379	(−293)
Total	9,326	9,184	(−142)	10,750	(+1,566)	9,863	(−887)

Table 3.—Total number of licenses, by size class, for years 1979-82 from TPWD license records. Parenthetical entries represent the percentage of total licenses held by a given size class for a given year.

Size class (length in feet)	Total licenses							
	1979		1980		1981		1982	
≤25	4,345	(47)	3,978	(43)	4,702	(44)	4,190	(42)
25-40	2,511	(27)	2,736	(30)	3,151	(29)	3,070	(31)
40-55	832	(9)	929	(10)	1,095	(10)	1,049	(11)
55-70	1,246	(13)	1,142	(12)	1,355	(13)	1,178	(12)
70<	392	(4)	399	(4)	447	(4)	376	(4)

Table 4.—Number of vessels in each size class that held a given license or license combination during 1979 from TPWD license records. Parenthetical entries represent the percentage of total licenses sold in each license or license combination category. Bracketed entries represent the percentage of vessels that held each license or license combination.

Size class (feet)	License or license combination						
	Bay	Bait	Gulf	Bay/Bait	Bay/Gulf	Bait/Gulf	All
≤25	2,060	341	426	177	429	24	86
25-40	339	87	66	453	109	23	283
40-55	56	7	74	53	4	56	153
55-70	7	0	1,152	3	21	3	11
70<	1	1	378	4	1	1	0
Total	2,473	436	2,096	690	564	107	533
% of total licenses	(26.5)	(4.7)	(22.5)	(14.8)	(12.1)	(2.3)	(17.1)
% of vessels	[35.8]	[6.3]	[30.4]	[10.0]	[8.2]	[1.6]	[7.7]

Table 5.—Number of vessels in each size class that held a given license or license combination during 1980 from TPWD license records. Parenthetical entries represent the percentage of total licenses sold in each license or license combination category. Bracketed entries represent the percentage of vessels that held each license or license combination.

Size class (feet)	License or license combination						
	Bay	Bait	Gulf	Bay/Bait	Bay/Gulf	Bait/Gulf	All
≤25	1,709	395	422	214	364	34	76
25-40	294	116	77	496	110	43	317
40-55	39	13	73	65	51	16	180
55-70	9	0	1,056	3	20	2	9
70<	0	0	391	0	4	0	0
Total	2,051	524	2,019	778	549	95	582
% of total licenses	(22.3)	(5.7)	(22.0)	(16.9)	(12.0)	(2.1)	(19.0)
% of vessels	[31.1]	[7.9]	[30.6]	[11.8]	[8.3]	[1.4]	[8.8]

Table 6.—Number of vessels in each size class that held a given license or license combination during 1981 from TPWD license records. Parenthetical entries represent the percentage of total licenses sold in each license or license combination category. Bracketed entries represent the percentage of vessels that held each license or license combination.

Size class (feet)	License or license combination						
	Bay	Bait	Gulf	Bay/Bait	Bay/Gulf	Bait/Gulf	All
≤25	2,145	318	371	298	418	37	122
25-40	345	94	75	579	127	26	391
40-55	53	8	131	66	47	16	215
55-70	9	1	1,183	2	60	1	12
70<	1	1	435	0	5	0	0
Total	2,553	422	2,195	943	657	80	740
% of total licenses	(23.7)	(3.9)	(20.4)	(17.5)	(12.2)	(1.5)	(20.7)
% of vessels	[33.6]	[5.5]	[28.9]	[12.4]	[8.6]	[1.0]	[9.7]

Table 7.—Number of vessels in each size class that held a given license or license combination during 1982 from TPWD license records. Parenthetical entries represent the percentage of total licenses sold in each license or license combination category. Bracketed entries represent the percentage of vessels that held each license or license combination.

Size class (feet)	License or license combination						
	Bay	Bait	Gulf	Bay/Bait	Bay/Gulf	Bait/Gulf	All
≤25	1,743	369	455	274	343	40	103
25-40	323	118	86	563	114	56	359
40-55	46	17	78	67	57	18	208
55-70	10	0	1,032	3	52	1	8
70<	1	1	366	1	2	1	0
Total	2,123	505	2,017	908	568	116	678
% of total licenses	(21.5)	(5.1)	(20.4)	(18.4)	(11.5)	(2.4)	(20.6)
% of vessels	[30.7]	[7.3]	[29.2]	[13.1]	[8.2]	[1.7]	[9.8]

The proportion of licenses held by a given size class was consistent with the proportion of vessels of that size class participating in the fishery. Small vessels (<25 feet) held the majority (44 percent) of licenses. In contrast large Gulf vessels (>70 feet) held only 4 percent of all licenses (Table 3). It should be noted that the proportion of licenses held by a given size class remained constant over the 4-year span. A comparison of the number of licenses purchased for each of the three commercial fisheries shows that the most popular license was the single bay license, accounting for about one-fourth of the total of all license combinations (Tables 4, 5, 6, 7). Roughly one-third of all vessels operated

under this license alone. The second most popular license was the single Gulf license, accounting for about one-fifth of all license combinations. Slightly less than one-third of the fleet operated under this license alone. Although the single bait licenses accounted for only about 5 percent of all licenses held, bait licenses alone and in combination with other licenses accounted for roughly one-fifth of all licenses held (Table 2).

The percentage of vessels in the fleet maintaining more than one license increased from 28 percent (1979) to 33 percent (1982). However, over half of the vessels holding more than one license were 25-40 feet or 40-55 feet in length. About 8-10 percent of the fleet maintained a combination of all three licenses; however, vessels in the 25-40 foot and 40-55 foot classes accounted for the majority (84 percent) of multiple (bay/bait/Gulf) licenses held during 1982 (Table 7). Among the license combinations, the bait/Gulf combination was the least popular. This is not surprising since the vessel and gear requirements for the two fisheries are not highly compatible.

Comparison of the bay, bait, and Gulf fisheries with regard to the number of commercial licenses held by a given vessel size class indicates that three-fourths of the licenses held by vessels 25-40 feet and 40-55 feet in length were bay and bait licenses. One-fourth of the licenses maintained were Gulf licenses (alone and in combination with other licenses), although single Gulf licenses accounted for only 4 percent of all licenses held. Vessels greater than 55 feet held almost exclusively Gulf licenses; bay and/or bait licenses represented roughly 5 percent of all licenses held by these vessels.

Table 8.—Number of home ports claimed by vessels in each size class during 1980-82 from TPWD license records.

Size class (length in feet)	No. of home ports		
	1980	1981	1982
≤25	212	221	216
25-40	80	94	93
40-55	42	48	44
55-70	54	67	62
70<	43	42	43
Total	431	472	458

Table 9.—Number of out-of-state home ports claimed by vessels in the three largest size classes during 1980-82 from TPWD license records.

Size class (length in feet)	Out-of-state home ports		
	1980	1981	1982
40-55	11	9	7
55-70	35	39	38
70<	19	20	19

Table 10.—Number of vessels in each size class that used each of 15 major Texas ports during 1980. Parenthetical entries represent the percentage of vessels of the indicated size that used one of the 15 major ports.

Home port	No. of vessels (by size class[1])					
	≤25	25-40	40-55	55-70	70<	Total vessels
Rockport/Fulton/ Aransas/Corpus Christi	207	335	85	263	54	944
Galveston	180	239	121	139	69	748
Houston	353	93	47	17	0	510
Brownsville/Pt. Isabel	36	16	11	314	94	471
Baytown	166	32	5	0	0	203
Beaumont	164	11	0	2	0	177
Pt. Arthur	125	25	22	20	3	195
Kemah/Seabrook	74	106	6	3	1	190
Texas City	120	33	2	0	0	155
Freeport/Brazoria	71	31	1	7	2	112
Pt. Lavaca	34	51	24	16	7	132
Palacios	29	87	16	20	13	165
San Leon/Dickinson	70	46	2	0	0	118
Seadrift	22	65	22	1	0	110
Orange	40	1	0	1	0	42
Total	1,691	1,171	364	803	243	4,272
% using a major port	(52.6)	(80.6)	(83.3)	(73.1)	(61.5)	(64.7)

[1]Length in feet.

Home Ports

The number of home ports claimed by commercially licensed vessels remained relatively constant from 1980 to 1982 (Table 8). Vessels <25 feet in length claimed the largest number of home ports. This is most likely due to the fact that small boats are transported easily and do not necessarily require close affiliation with a specific ice house, fuel dock, or market (Warren, 1979). Roughly half of the home ports claimed by vessels >55 feet in length were out-of-state (Tables 8 and 9). The number of out-of-state home ports for Gulf vessels remained constant from 1980 through 1982.

Fifteen ports served approximately half the fleet (Tables 10-12). The Rockport/Fulton/Aransas/Corpus Christi, Galveston, Brownsville, and Houston ports were among the most important ports in Texas during 1980-82. These ports supported a significant number of bay, bait, and Gulf vessels. In terms of licenses, Brownsville was primarily a Gulf fishing port, whereas Baytown, Kemah/Seabrook, Pt. Lavaca, Seadrift, and San Leon were primarily bay and bait fishing ports (Table 13). Houston was a primary home port for 455 vessels. Although the majority of vessels were small (<40 feet), 112 licenses held at these ports were Gulf licenses. Similarly, Beaumont supported mostly small vessels (<25 feet); however, 62 percent of the licenses held at these ports were Gulf licenses (Tables 12 and 13). This suggests that these ports were popular ports for a large number of part-time or recreational fishermen.

Roughly 50 percent of vessels less than 25 feet in length utilized the 15 major ports and the majority of licenses were bay licenses (Table 14). Between 80 and 85 percent of vessels 25-40 feet and 40-55 feet in length used the 15 major ports as their home ports during 1982, with bay and bait licenses being

Table 11.—Number of vessels in each size class that used each of 15 major Texas ports during 1981. Parenthetical entries represent the percentage of vessels of the indicated size that used one of the 15 major ports.

Home port	No. of vessels (by size class[1]) ≤25	25-40	40-55	55-70	70<	Total vessels
Rockport/Fulton/ Aransas/Corpus Christi	214	354	91	258	53	970
Galveston	191	276	126	151	36	780
Houston	350	105	54	13	0	522
Brownsville/Pt. Isabel	42	15	13	306	86	462
Baytown	207	39	4	1	0	251
Beaumont	197	10	0	1	0	208
Pt. Arthur	111	33	31	25	3	203
Kemah/Seabrook	79	121	7	3	0	210
Texas City	106	45	4	0	0	155
Freeport/Brazoria	90	38	0	15	2	145
Pt. Lavaca	40	58	33	20	3	154
Palacios	39	98	19	24	13	193
San Leon/Dickinson	84	47	5	0	0	136
Seadrift	46	71	25	1	0	143
Orange	72	4	0	1	0	77
Total	1,868	1,314	412	819	196	4,609
% using a major port	(50.4)	(80.3)	(76.9)	(64.6)	(44.3)	(60.7)

[1]Length in feet.

Table 12.—Number of vessels in each size class that used each of 15 major Texas ports during 1982. Parenthetical entries represent the percentage of vessels of the indicated size that used one of the 15 major ports.

Home port	No. of vessels (by size class[1]) ≤25	25-40	40-55	55-70	70<	Total vessels
Rockport/Fulton/ Aransas/Corpus Christi	208	365	95	234	41	943
Galveston	167	267	125	121	35	715
Houston	284	105	47	18	1	455
Brownsville/Pt. Isabel	50	13	10	306	80	459
Baytown	177	36	4	0	1	218
Beaumont	185	7	0	1	0	193
Pt. Arthur	122	38	33	28	1	222
Kemah/Seabrook	67	109	10	1	0	187
Texas City	88	53	9	0	0	150
Freeport/Brazoria	77	42	3	6	1	129
Pt. Lavaca	38	55	32	18	1	144
Palacios	34	88	19	22	13	176
San Leon/Dickinson	70	52	4	0	0	126
Seadrift	29	72	24	1	0	126
Orange	77	6	0	0	0	83
Total	1,673	1,308	415	756	174	4,326
% using a major port	(50.3)	(80.1)	(84.5)	(68.4)	(46.8)	(62.6)

[1]Length in feet.

Table 13.—Number of licenses by fishery (bay, bait, or Gulf) for each of 15 major Texas ports, during 1982 only, from TPWD license records.

Home port	No. of licenses represented Bay	Bait	Gulf
Rockport/Fulton/ Aransas/Corpus Christi	506	568	447
Galveston	479	371	423
Houston	415	126	112
Brownsville/Pt. Isabel	12	56	415
Baytown	208	59	14
Beaumont	142	12	106
Pt. Arthur	75	16	204
Kemah/Seabrook	153	100	57
Texas City	132	60	26
Freeport/Brazoria	66	53	76
Pt. Lavaca	116	53	43
Palacios	130	67	108
San Leon/Dickinson	113	59	21
Seadrift	114	67	46
Orange	23	1	73

Table 14.—Number of licenses held by vessel size class and type of fishery at 15 major Texas ports during 1982 only. Parenthetical entries represent the percentage of the total number of licenses held at all ports purchased by vessels claiming one of the 15 major ports as a home port.

Size class (length in feet)	No. of licenses Bay		Bait		Gulf	
≤25	1,177	(47.8)	468	(59.5)	460	(48.9)
25-40	1,116	(82.1)	913	(83.3)	494	(80.3)
40-55	330	(87.3)	288	(92.9)	299	(82.8)
55-70	57	(78.0)	11	(91.7)	748	(68.4)
70<	4	(100)	3	(100)	171	(46.3)

the primary licenses held. Between 47 and 69 percent of the vessels > 55 feet in length claimed major ports as their home ports during 1982 (Table 12).

Counties

The majority of owners of licensed vessels claimed Texas coastal counties as their county of residence (Table 15). The pattern of distribution for coastal residency by vessel size class was consistent from 1980 to 1982. As vessel size increased, the percentage of vessels claiming Texas coastal and Texas noncoastal residency decreased and out-of-state residency increased. This observation is consistent with the fact that as vessel size increased the percentage of vessels using one of the 15 major Texas ports as a home port decreased. In terms of ownership, proximity to the Texas Gulf coast was not a requisite for larger vessels. A number of the Gulf vessels 55-70 feet in length (16-22 percent) and greater than 70 feet in length (28-50 percent) were owned, but not necessarily

Table 15.—Residency of owners of commercially licensed vessels in each size class during 1980-82 from TPWD license records. Parenthetical entries represent the percentage of vessels in each residency category.

Year	Residency	No. of vessels (by size class[1]) ≤25		25-40		40-55		55-70		70<		Total vessels
1980	Texas coastal	2,855	(89)	1,370	(94)	392	(90)	918	(84)	285	(72)	5,820
	Texas noncoastal	352	(11)	76	(5)	13	(3)	18	(2)	6	(2)	465
	Out-of-state	7	(<1)	7	(<1)	32	(7)	163	(15)	104	(26)	313
	Total	3,214		1,453		437		1,099		395		6,598
1981	Texas coastal	3,248	(88)	1,500	(92)	442	(83)	989	(78)	222	(50)	6,401
	Texas noncoastal	375	(10)	70	(4)	11	(2)	11	(<1)	19	(4)	486
	Out-of-state	84	(2)	67	(4)	83	(16)	268	(21)	201	(46)	703
	Total	3,707		1,637		536		1,268		442		7,590
1982	Texas coastal	2,932	(88)	1,502	(92)	443	(90)	893	(81)	210	(57)	5,980
	Texas noncoastal	352	(11)	97	(7)	19	(4)	13	(1)	4	(1)	485
	Out-of-state	43	(1)	20	(1)	29	(6)	200	(18)	158	(42)	450
	Total	3,327		1,619		491		1,106		372		6,915

[1]Length in feet.

operated, by residents of out-of-state (coastal and noncoastal) or Texas noncoastal areas. In contrast, bay vessels were owned primarily by residents of coastal regions. Only 6-8 percent of the smaller bay vessels (25-40 feet) and 10-18 percent of the larger bay vessels (40-55 feet) were owned by noncoastal or out-of-state residents. This is not surprising since bay and bait shrimp boat owners were the primary operators of their vessels (Warren, 1979). Similarly, the majority of the small (<25 feet) boat owners claimed coastal residency.

From 1980 to 1981 the number of out-of-state owned vessels of all sizes dramatically increased (<25 feet = +1,100 percent; 25-40 feet = +857 percent; 40-55 feet = +159 percent; 55-70 feet = +65 percent; >70 feet = +93 percent), as did the number of Texas coastal county vessels in most size classes. From 1981 to 1982, out-of-state vessels decreased in number, although not as sharply as they had increased from 1980 to 1981 (<25 feet = −49 percent; 25-40 feet = −70 percent; 40-55 feet = −65 percent; 55-70 feet = −25 percent; >70 feet = −21 percent). The number of Texas coastal county vessels in some size classes also decreased slightly (less than 25 feet = −10 percent; 55-70 feet = −10 percent; greater than 70 feet = −5 percent). However, Texas coastal residency of owners of vessels in size classes 25-40 feet and 40-55 feet remained virtually constant.

Discussion

Because the Texas shrimp fishery is an open access resource it is subject to increasing amounts of fishing pressure and competition between harvesters as vessels enter the fishery on a continuous basis. Examination of the TPWD's licensing data indicates that despite yearly variation in vessel and license numbers the number of vessels participating in the shrimp fishery and the number of licenses that they hold have been increasing. The general dynamics of vessels entering and leaving the fishery, including the substantial expansion of the fleet in 1981, can be interpreted partially in light of management regulations and yearly economic fishery conditions.

In 1981 the Texas State Legislature passed Senate Bill 749, which states that during calendar years 1982 and 1983 a commercial bay and bait shrimp boat license may be issued only to persons who possessed a bay or bait shrimp boat license on 28 February 1981, or to any person who owned a boat that was at least 50 percent completed by 1 March 1981. This bill was intended to enhance fishing success and stabilize or reduce fishing effort in the inshore fishery. However, in response to these restrictions, members of the established shrimp fleet who had not traditionally fished in the bay and/or bait fisheries, as well as new entrants to the fleet, sought out these licenses. Owners of bay-licensed vessels also purchased bait licenses, and vice versa. By the end of 1981 bait and bay licenses had increased 19 percent over 1980 levels, although by 1982 bay and bait license numbers approximated those of 1979.

Traditionally, once limited entry schemes are initiated they are not easily repealed (Rettig and Ginter, 1978). Despite the initial 2-year legal limit on the moratorium, the response of fishermen to renew/apply for bay/bait licenses is understandable in light of the historical treatment of limited entry. Vessel owners and operators entered these fisheries to ensure future participation in them.

House Bill 1367, which allowed for a 200-pound daily bait catch and simultaneously eliminated the requirement to maintain live shrimp on board, may have contributed to the increase in purchases of bait licenses. This provision appears to be beneficial to bay boats (55 feet or less in length). Since the spring commercial catch is limited to a 300-pound limit, bay boats could effectively harvest an additional 200 pounds without incurring additional expenses to meet live holding tank gear requirements.

Finally, the 1981 Texas Legislature enacted Senate Bill 865 which called for a simultaneous closure of the territorial sea and the Fisheries Conservation Zone from 1 June to 15 July. This bill was intended to make the offshore fishery more profitable by allowing shrimp to grow larger before harvest. Given generally favorable fishery conditions (shrimp availability), it is speculated that offshore operators anticipated more profitable catches. Gulf license purchases for vessels 55 feet and over increased considerably in 1981, the first year of the closure. However, this decreased in 1982 to about the 1980 level.

In spite of changing economic conditions the year-to-year breakdown of vessel numbers participating in the shrimp fleet indicates that the number of vessels 25-40 feet and 40-55 feet in length did not vary greatly during the 4-year period examined. Decreases in fleet size (1980, 1982) resulted primarily from vessels less than 25 feet in length and vessels 55-70 feet in length leaving the fishery. A possible explanation for this trend may be that for recreational and occasional fishermen fishing for shrimp is a luxury activity and is not worth the investment during times of personal economic stress. Likewise, some large Gulf vessels which are costly to operate would incur fewer losses by not fishing at all. In contrast, vessels 25-40 and 40-55 feet in length would be more likely to remain in the fishery, despite an economically unprofitable year, because of less overhead and other outside sources of income (Warren, 1979). Given the resiliency of the shrimp stock and fluctuating market prices it is not unreasonable for a vessel owner to have expectations of future profitability or, at worst, break-even conditions.

An important descriptor of the Texas shrimp fishery is the substantial number of combination shrimp licenses held by individual vessels. Shrimp vessels are outfitted such that their versatility for utilization in other fisheries is limited. Thus, shrimp vessel operators may increase their fishing options by harvesting in different sectors of the shrimp fishery. Vessels 25-40 feet and 40-55 feet in length were the primary holders of combination or multiple licenses. Since these vessel classes participated primarily in inshore bay or bait fisheries, their total landings were assumed to be inshore landings. However, the relatively high proportion of multiple licenses held by the inshore vessels suggests potential mobility into the Gulf sector when the weather permits and the shrimp are in

season. It is likely that typically inshore fishermen supplement their harvest in Gulf waters. Thus a portion of the landings attributed to the inshore fishery may be harvested in offshore Gulf waters.

Aggregation of vessels into five distinct size classes was based on prior observations which associated vessel size with type of license held. The current quantitative analysis verified these observations. Vessels 25-40 feet, 40-55 feet, 55-70 feet, and >70 feet in length represented primarily full-time commercial operators, and it is these groups that have been represented in studies of the shrimp fishery. Vessels <25 feet in length have been presented as representing part-time, occasional commercial, and recreational fishermen. This group held about 43 percent of all commercial shrimp licenses during the early 1980's. However, to date, very little is known about this fishing population. Considering the high proportion of vessels and licenses in this class a finer definition of its members and further understanding of their fishing effort and harvest is recommended.

Conclusions

While the Texas shrimp fleet expanded and contracted on a yearly basis from 1975 to 1982, the total number of vessels in the fishery increased in a generally linear fashion during this period. The number of bay and Gulf licenses fluctuated on a yearly basis from 1979 to 1982. In contrast, the number of bait licenses steadily increased during this period.

The percentage of vessels in the fleet maintaining more than one license increased from 1979 to 1982. Over half of the vessels holding more than one commercial shrimp license were 25-40 or 40-55 feet in length.

Fifteen Texas ports served about half the fleet. Between 80 and 85 percent of all vessels 25-55 feet in length claimed Texas ports as their home ports. And, the majority of owners of licensed vessels claimed Texas coastal counties as their county of residence.

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Fish or Fish Oil in the Diet and Heart Attacks

MAURICE E. STANSBY

Introduction

Research has shown that polyunsaturates in the human diet reduce serum cholesterol levels and probably thereby reduce risk of heart attacks, whereas saturated fatty acids exert the opposite effect. Fish contain certain polyunsaturates but also often equivalent amounts of saturates. Vegetable oils, on the other hand, contain principally polyunsaturates.

Nevertheless, fish oils reduce serum cholesterol levels to a greater extent than do vegetable oils (Peifer et al., 1960). While work on effect of polyunsaturates of fish oil on serum cholesterol levels was being done, a 20-year clinical study (Nelson, 1972) indicated that fish oils were much more effective in reducing incidence of fatal heart attacks in heart patients than were any other polyunsaturated oils. The reasons for these differences, which seemed quite illogical, were then unknown.

ABSTRACT—Recent research has shown that fish oil (or oil in fish), in addition to its role as a serum cholesterol depressant, also contains long-chain omega-3 fatty acids which may directly lower the risk of heart attacks. The only dietary source of these omega-3 fatty acids are fish flesh or fish oil. They can, at present, best be obtained by increasing consumption of fish in the diet. Efforts are underway to find an inexpensive way of producing fish oil concentrates for taking in capsule form. Until this happens, the best way to increase the omega-3 fatty acids in the human diet is to increase the consumption of fish.

Recent Research Findings

Current research, some of which began a little over a decade ago, is revealing the reasons for the superior effectiveness of fish oils. Much of this research prior to 1981 has been summarized in the last three chapters of a recent book (Barlow and Stansby, 1982). This research has shown that the omega-3 long-chain fatty acids found in food to any considerable extent only in oils of marine origin can act to reduce blood platelet aggregation and thereby reduce the risk of heart attack. This effect is quite separate and in addition to the well known reduction of serum cholesterol levels by polyunsaturates.

Research was begun in the early 1970's to determine why Eskimos in remote areas of Greenland almost never suffered heart attacks. It was found that the protection against heart attacks was associated with the Eskimo diet which consisted almost entirely of the flesh of marine fish or marine animals. Further research related the effect to the presence of eicosapentaenoic acid and possibly other long-chain omega-3 fatty acids derived from the Eskimo's marine food (Dyerberg, 1982).

Most of the original work by Dyerberg and his co-workers (Dyerberg, 1982) focused on the omega-3 fatty acid, eicosapentaenoic acid, as the fish oil fatty acid involved in decreased platelet aggregation. For some time it was assumed by many researchers that only the eicosapentaenoic acid was effective in this role.

This idea perhaps originated from the analogy that eicosapentaenoic acid very closely resembles the chemical structure of arachidonic acid, the former having merely an additional double bond in the omega-3 position. In the normal diet, arachidonic acid is the fatty acid which acts as the precursor for prostaglandin formation. Thus the theory probably developed from assuming that the eicosapentaenoic acid, replacing the very similarly structured arachidonic acid, was required to bring about the metabolism involving omega-3 structured fish oil fatty acids to prostaglandins which could then diminish thrombotic events.

At a London symposium on nutritional evaluation of long-chain fatty acids of fish oils in October 1981, a portion of the papers and the subsequent discussion dealt with the role of fish oils in alleviating heart disease and other conditions. During the discussion following the paper presentations, the matter of whether only eicosapentaenoic acid was required or if other omega-3 fatty acids were involved was considered in some depth (Barlow and Stansby, 1982:307-311). Partly based upon his earlier work (Lands et al., 1973), W. E. M. Lands concluded that the diminishment of thrombotic events was caused by activity of any long-chain omega-3 fatty acid to inhibit prostaglandin biosynthesis. Even J. Dyerberg, al-

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though indicating that most of his research dealt with eicosapentaenoic acid, also felt that other long-chain omega-3 fatty acids could be involved.

Today, the opinion seems to be gaining favor that any long-chain omega-3 fatty acids may be involved. In fact, there is some belief that the more highly polyunsaturated fatty acids such as docosahexaenoic acid may be even more effective in this regard than eicosapentaenoic acid. Manufacturers of long-chain fish oil polyunsaturated concentrates for dietary use are now emphasizing production of mixtures of omega-3 fatty acids or of increasing the content in such concentrates of the docosahexaenoic acid.

Since the first publications in Denmark presenting ideas on the reasons for virtual immunity of Greenland Eskimos to heart attacks, well over 100 scientific papers have confirmed and extended these results. These studies have been underway in many different laboratories throughout the world. In addition to the work on the mechanism for the action of omega-3 fatty acids from fish oil influencing through prostaglandins formation formed in such a way as to decrease platelet aggregation and thereby to reduce incidence of heart attacks, many papers have shown a similar mechanism for the action of anti-inflammatory drugs such as aspirin on heart attacks. Three European scientists won in 1982 the Nobel prize in medicine for this work. One of these three (John Vane) had authored with Dyerberg a paper (Dyerberg et al., 1978) on this effect when fish oil was involved.

In addition to this effect on heart attacks, apparently with some animals by a similar mechanism, omega-3 fish oil fatty acids can affect the severity of the after-effects of strokes. In experiments with cats, Lands (1982) showed that those animals fed omega-3 fatty acids from fish oils showed a decrease in the extent of such effects.

Serum Cholesterol vs. Omega-3 Effects

Much of the early work on serum cholesterol depressant activity of fish oil (summarized by Stansby, 1969) showed merely that fish oil was at least as effective, usually more so, as other polyunsaturated oils in lowering serum cholesterol levels. In most cases where population groups (e.g. Japanese fishermen's families with high fish consumption rates) had diminished thrombotic events, it was assumed that the effects upon decreased heart attacks were due solely to reduction in serum cholesterol levels. Recent research on families of Japanese fishermen (Hirai et al., 1980; Kobayashi et al., 1981) confirms that at least a part of the effect stems from intake of eicosapentaenoic acid.

In the 20-year study of Nelson (1972), the use of increased fish in the diet resulted in decrease of subsequent fatal heart attacks to less than one-fourth of that of the controls. In the absence of any other causes known at that time, the results were laid to lowering of serum cholesterol levels. At this late date, there is no way to discriminate as to cause. However, since the reduction in fatal heart attack was far greater than in any other known clinical experiment, it now seems highly probable that the newer discovered omega-3 mechanism was partly involved.

Very recent research has been concerned to a large extent with determining more precisely the mode whereby the ingestion of omega-3 fatty acids bring about decreased platelet aggregation. The question as to whether the effect is due primarily to eicosapentaenoic acid or to other long-chain fish oil omega-3 fatty acids as well is a difficult one to answer. The two most commonly occurring such acids in fish oils are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). In oils from some species EPA occurs to the greatest extent; in others DHA predominates. There is always, however, more by far of either of these two omega-3 fatty acids than any others. It is very difficult and expensive to separate DHA from EPA. While for gas chromatography standards of pure DHA or EPA is available, the cost is so great (around $100/g) that it makes use of these pure long-chain omega-3 fatty acids prohibitively expensive for research on their respective mode of action. In such work, it is common to use either fish oils or manufactured concentrates of EPA and DHA. Such research does not permit discriminating as to the effectiveness of either since both occur often at about equal concentrations.

While many current investigators are assuming that the main effect of the omega-3 fatty acid is a matter of incorporation of the omega-3 characteristics into the prostaglandin, it must be remembered that there is an entirely different mode of action which may be important involving inhibition of production of prostaglandins. Lands et al. (1973), showed that polyunsaturated omega-3 long-chain fatty acid inhibited prostaglandin synthesis, and the greater the degree of polyunsaturation, the greater was this inhibition effect.

Most of the very recent research has employed in vitro experiments on the role of EPA or a mixture of EPA with other omega-3 fatty acids on aggregation of platelets, but Fisher and Weber (1984) have shown, using in vivo techniques applied to human subjects, that mackerel oil high in EPA forms prostaglandin I_3.

In other recent work the commercially sold concentrate of EPA and DHA, Maxepa[1], which contains roughly equivalent amounts of EPA and DHA, has been investigated for its effect on platelet function in human patients (Sanders and Roshanai, 1983; Saynor et al., 1984). In both studies, positive effects were obtained upon the platelet function. It is interesting to note, however, that in the work of one laboratory (Saynor et al., 1982) the entire effect was laid to the EPA present and it was not even mentioned that DHA was present in the Maxepa used in the experiment. On the other hand, in a paper from a different laboratory using the same Maxepa product (Sanders et al., 1983), credit for the effects was attributed to both EPA and DHA.

Dietary Consumption of Omega-3 Fatty Acids in Fish Oil Concentrates

Dietary omega-3 fatty acids can be

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

increased either by consumption of concentrates of fish oil in capsules or by increasing the amount of fish in the diet. At present there is one such encapsulated fish oil product available for sale in the United States. However, it is so expensive that it would cost about $600/month for an individual to attain the same dietary level of omega-3 fatty acids as did the Greenland Eskimos who rarely suffered heart attacks.

Cheaper ways of concentrating omega-3 fatty acids in fish oils are being studied. Initially fish oil concentrate manufacturers believed that the single omega-3 fatty acid with chain length of 20 carbon atoms and five double bonds (EPA) was the only effective one for reducing heart attacks. However, it remains difficult and expensive to isolate a single fatty acid.

Now, however, with the likelihood that any long-chain omega-3 fatty acid will be at least as effective as EPA in bringing about the desired effect, efforts are underway in several countries, especially in Japan, to develop a better and cheaper method of concentrating the omega-3 fatty acids. Meanwhile, the most practical way to obtain omega-3 long-chain fatty acids is to eat more fish.

Omega-3 Fatty Acids From Fish in the Diet

Consumers who wish to improve their dietary levels of long-chain omega-3 fatty acids should select fish of relatively high oil content. The oil content of fish flesh may vary by more than 200 times (from 0.1 to 20 percent or more). This is not just a matter of variation from species to species. The oil content in flesh even of the same species may vary by more than ten times depending upon the area and season in which the fish is harvested. The oil content is controlled by the particular feed available to the fish.

The content of long-chain omega-3 fatty acids in fish of different species also varies to some extent but this variation is much less important in selection of fish for their omega-3 content than is the fat or oil content. While the content of any one long-chain omega-3 fatty acid may vary considerably in oils from different fish species, the sum total of all long-chain omega-3 fatty acids has a much smaller variation.

Ways to select fish of high oil content based upon such factors as choosing cuts of fish from near the head where the oil content is greatest have been discussed in an earlier paper by Stansby (1973).

Greater consumption of fish generally considered to have high or medium oil content (Stansby, 1962) would be most desirable. These are species of fish in which the oil content, while varying considerably, is nearly always at least 5 percent. Examples include herring, mackerel, rainbow trout, all species of salmon (except chum), sardines, and albacore (if caught near California).

Low oil content fish vary in oil content from 0.1 to 5 percent. Those species in the upper range of this category (2 to 5 percent) furnish enough omega-3 long-chain fatty acids to be useful as a limited supply of such acids. Fish in this category include most tunas, carp, chum salmon, mullet, swordfish, and Great Lakes white fish. For shellfish such as oysters and clams, although the oil content usually does not exceed 1 percent, the oil is considerably higher in the omega-3 long-chain fatty acids. Such shellfish, therefore, can be included in this category despite their lower oil content.

Most of the species of fish listed here are available in the fresh state for only a part of the year. An exception are fish like rainbow trout which are grown by aquaculture and are available year-round. Rainbow trout also is one of the species with the highest total omega-3 long-chain fatty acids content. Canned albacore (which can be identified by the label "white meat" tuna) can contain considerable amounts of omega-3 long-chain fatty acids if the fish have been caught close to California. Other canned albacore and other canned tunas have a lower oil content and hence less of the omega-3 fatty acids.

Level of Omega-3 Fatty Acids Needed to Insure Some Significant Diminishment in Heart Attacks

It is much too early to reach any conclusion as to the minimum amount of fish or omega-3 fatty acids in the diet which is required to significantly reduce the likelihood of heart attacks. The Greenland Eskimo diet was nearly 100 percent fish. It is reasonable to assume that at a lower level of consumption of fish, some decrease in risk of heart attacks might occur even though not reaching nearly the practical immunity enjoyed by the Eskimos. Unfortunately, current research has made little attempt to address this problem. In most cases, in recent research the level of omega-3 fatty acids fed has been at very high levels sometimes approaching those in the diet of the Eskimos. This might require eating over a pound of fish per day or taking very considerable amounts of fish oil. In some instances where several levels of omega-3 fatty acids were fed, there has been some measurable decrease in platelet aggregation at the lower levels. This might or might not result in decreased risk of heart attacks.

In the case of the heart patients of Averly Nelson (Nelson, 1972) where those consuming fatty fish at least three times per week for periods of time from 16 to 19 years had only about 25 percent as many fatal heart attacks as in the control group, it seems likely that this difference could have been caused at least in part by a decreased level of platelet aggregation. Undoubtedly, if continued success is achieved in research now underway, experiments will be designed and carried out on effects of different levels of omega-3 fatty acids in the diet.

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U.S. Commercial Fishermen Land 6.4 Billion Pounds of Fish in 1983

United States fishermen landed 6.4 billion pounds of edible and industrial fish last year, up about 71 million pounds from 1982 landings and just short of the 1980 record of 6.5 billion pounds. Despite the 1983 catch increase, the price paid for those fish at the dock, $2.4 billion, decreased by $34.5 million compared with 1982.

Record landings of American lobster and menhaden and increased landings of clams, cod, flounder, salmon, and tuna helped offset declines in other major species including anchovies, shrimp, and squid. The end result was that fishermen received about a penny a pound less for their fish and shellfish in 1983 than they did in 1982.

Records Set

A number of records were set in 1983. They include landings of 3.0 billion pounds of industrially-important menhaden (the previous high was 2.8 billion pounds in 1982); 44.2 million pounds of American lobster worth $106.8 million (the previous high was 39.4 million pounds worth $90.9 million in 1982), and exports of 404.1 million pounds of fish oils (the previous high was 284.0 million pounds in 1980).

Among the losers were king crab, with landings of 25.6 million pounds, the lowest level since 1959, and anchovies, which showed an equally dramatic plunge, down from 103.3 million pounds in 1982, to only 22.3 million pounds last year.

Top Fishing Ports

New Bedford, Mass., led all other U.S. cities in the value of its fish landings in 1983, and Cameron, La., led all others in the volume of its catch. Specifically, New Bedford led with more than $109 million worth of fish and shellfish landed, up substantially from $83.3 million in 1982. Cameron, as in the past 6 years, was first in volume, with 744 million pounds of fish landed, mostly the lower-valued menhaden.

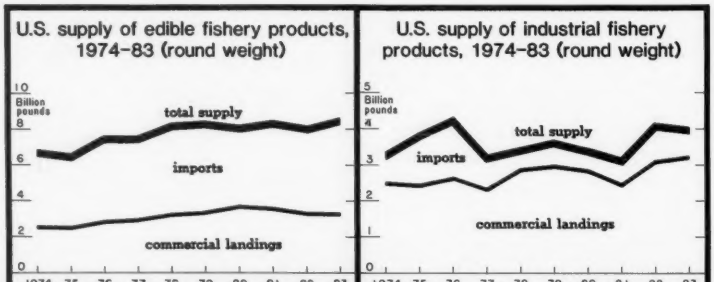
The most dramatic shifts resulted from continued lower landings of tuna in California, which caused values in the Los Angeles and San Diego areas to continue to tumble, and a crash in the king crab fishery which brought Kodiak, Alaska, landings to less than half their 1981 value.

The ten leading U.S. ports in volume of fish and shellfish landed in 1983 (in millions of pounds), with 1982 figures for comparison were:

	1983	1982
Cameron, La.	743.9	714.7
Pascagoula-Moss Point, Miss.	380.2	331.6
Empire-Venice, La.	281.9	267.3
Dulac-Chauvin, La.	269.2	265.6
Los Angeles Area, Calif.	262.3	334.8
Beaufort-Morehead City, N.C.	167.2	116.4
Gloucester, Mass.	150.9	146.6
New Bedford, Mass.	111.8	94.9
Kodiak, Alaska	89.0	105.3
San Diego, Calif.	84.6	106.8

The ten leading U.S. ports in value of fish and shellfish landed in 1983 (in millions of dollars), with 1982 figures for comparison were:

	1983	1982
New Bedford, Mass.	109.2	83.3
Los Angeles Area, Calif.	85.1	92.9
Kodiak, Alaska	60.4	90.1
Brownsville-Port Isabel, Tex.	55.0	52.0
Aransas-Rockport, Tex.	50.0	41.0
Dulac-Chauvin, La.	47.7	51.7
Cameron, La.	39.5	40.4
Gloucester, Mass.	38.0	43.6
San Diego, Calif.	37.5	59.7
Dutch Harbor-Unalaska, Alaska	36.4	47.8


U.S. supply of edible fishery products, 1974–83 (round weight)
Billion pounds
total supply
imports
commercial landings
1974 75 76 77 78 79 80 81 82 83
U.S. supply of industrial fishery products, 1974–83 (round weight)
Billion pounds
total supply
imports
commercial landings
1974 75 76 77 78 79 80 81 82 83

U.S. Shrimp Imports and Consumption Set Records

According to preliminary figures, U.S. landings of shrimp in 1983 were down from a year earlier, while imports and consumption reached record levels. Prices averaged slightly lower to slightly higher in 1983 compared with 1982, but most were 10-24 percent lower in December 1983 than a year earlier. Prices of the largest sizes were strongest, and prices of middle sizes were weakest.

Gulf and South Atlantic landings were 141 million pounds (heads-off) in 1983, down 5 percent from 1982, and 12 percent below the 1978-82 average. The value was $485 million, down 0.1 percent, according to preliminary estimates. The largest drop occurred in Louisiana. Among species, brown shrimp was down significantly, while whites and pinks were up somewhat.

U.S. supply and use of fresh and frozen shrimp, 1982-83[1] (in millions of pounds, heads-off).

Item	Supply	
	1982	1983
Beginning inventory	52.4	49.2
Landings[2]	149.2	141.2
Imports	302.4	388.0
Total supply	504.0	578.4
Ending inventory	49.2	56.8
Exports	31.1	28.3
Canned pack[3]	9.6	12.2
Apparent consumption	414.1	481.1

[1]Some data preliminary; totals from unrounded data.
[2]Gulf and South Atlantic only.
[3]Gulf only.

U.S. imports of fresh and frozen shrimp were a record 388 million pounds (heads-off) in 1983, up 28 percent from a year earlier and 50 percent above the 1978-82 average. Imports of all shrimp totaled 341 million pounds (product weight), valued at $1,224 billion. Imports from Mexico were up 5 percent to 84.6 million pounds ($384 million). Imports from Ecuador advanced sharply—up 42 percent—to 51.4 million pounds ($219 million). Based on shrimp farming primarily, imports from Ecuador grew from averages of 6.7 million pounds in 1968-72 and 21.1 million pounds in 1978-82. Counting Ecuador alone, aquaculture represented perhaps 13 percent of U.S. imports of shrimp in 1983, and future supplies from shrimp farms will be much larger. (See related article in Foreign Fisheries Development section.)

Inventories of frozen shrimp were 57 million pounds (heads-off) at the end of 1983, 15 percent above a year earlier, but 5 percent below the 1978-82 average. The Gulf pack of canned shrimp rose 27 percent to 12 million pounds (heads-off). Consumption of fresh and frozen shrimp in 1983 reached a record 481 million pounds, 16 percent above 1982, and 30 percent above the 1978-82 average.

Ex-vessel and wholesale prices of most Gulf shrimp were trending downward in the second half of 1983. Although prices of larger shrimp began turning upward in the last quarter, most prices closed lower in 1983 than in 1982. Wholesale prices of Gulf browns at New York were 4-18 percent lower in December 1983 than a year earlier, except for under 15's, which were 0.5 percent higher. Ex-vessel prices of western Gulf shrimp were 10-22 percent lower. The greatest declines were in the middle sizes. For the year, ex-vessel and wholesale prices averaged 5.7 percent higher to 1.8 percent lower.

U.S. 1983 Albacore Landings Up from 1982

Michael Laurs, Leader of the Fisheries Environment Investigations at the La Jolla Laboratory of the NMFS Southwest Fisheries Center, reports that the preliminary estimated catch for the 1983 U.S. albacore fishery is between 10,500 and 11,000 tons. While this total is about 30 percent below the 10 year average of 15,675 tons, it is about 40 percent higher than the catch landed in 1982, which was about 7,650 tons. Several factors contributed to the increased catch in 1983, including oceanographic conditions, in part associated with the El Niño, relatively good weather (especially off central and northern California), and a more stable market for fish-buying for processors.

Albacore arrived in waters south of Pt. Conception about a month earlier than usual, and fair catches were made until the end of July. After July, catches became virtually nil for the remainder of the season owing to very warm upper-layer ocean temperatures and deep thermocline conditions associated with the El Niño. While oceanographic conditions related to the El Niño were detrimental to albacore fishing south of Pt. Conception and in much of the Pacific Northwest, the El Niño was partly responsible for the best albacore fishing in a number of years off central and northern California. Water conditions were favorable, oceanic fronts important for the aggregation of albacore were close to shore, and weather conditions were generally good, resulting in the best fishing conditions and catch rates for several seasons between Pt. Conception and Eureka.

In coastal waters off much of Oregon and Washington, however, except for brief periods in local areas, e.g., off the Columbia River, Newport, Coos Bay, etc., albacore catches were generally low owing in large part to the lack of upwelling fronts to concentrate fish. Some of the best albacore fishing during the 1983 season occurred about 1,000 miles off northern Oregon, where a large fleet of boats made high catches for a number of weeks during August to late September. There was relatively good fishing in coastal waters off British Columbia for brief periods in the latter part of the season, as is usually the case.

The albacore fishing accurately reflected the albacore forecast prepared by Laurs and his staff in early June prior to the start of the 1983 season. In addition to the seasonal forecast, albacore fish bulletins detailing fishery information were issued biweekly by the Investigation Staff.

Daily albacore fishing broadcasts were also made during the 1983 fishing season, as they have been since 1967. In all, 72 broadcasts were made this year over 9 radio stations twice daily by Ron Dotson, Fishery Biologist, who prepared the broadcasts, based on information gathered from contacts with fishermen, fish buyers, fish processors, and State agency personnel.

Sablefish Assessment Made Off Alaska

The 1983 assessment survey for sablefish off southeast Alaska compared catch rates of conical and rectangular traps and provided estimates of relative abundance of prerecruit and marketable size sablefish. The ratio of catches in conical traps to catches in rectangular traps did not differ significantly from 1.0, showing that either type trap may be used for survey purposes. Compared with 1982, catch rates of marketable sablefish increased, reversing a downward trend evident for several years. Abundance of prerecruit sablefish continued to increase throughout the survey area. The increased abundance of sablefish in southeast Alaska is believed to be a result of the relatively strong 1977 year class.

U.S. Delegates Gain High Posts in New Salmon Organization

Representatives of several nations gathered earlier this year in Edinburgh, Scotland, for the inaugural meeting of the North Atlantic Salmon Conservation Organization (NASCO). NASCO, established under an international treaty which came into force on 1 October 1983, is composed of a Council and three Regional Commissions. Countries signing the treaty include Canada, Denmark (in respect to the Faroe Islands), the European Economic Community, Iceland, Norway, Sweden, and the United States. Finland also took part in the meeting as an observer and is expected to join NASCO.

The U.S. delegation to the Edinburgh meeting consisted of the three U.S. Commissioners to NASCO—Allen E. Peterson, Jr., of Sandwich, Mass.; Frank E. Carlton, Jr., of Savannah, Ga.; and Richard A. Buck of Dublin, N.H.—as well as government advisors and scientists.

At the meeting, Peterson, Director of the National Marine Fisheries Service's Northeast Fisheries Center in Woods Hole, Mass., was appointed by the multinational delegation as Vice President of NASCO's Council. Also, Buck, well known salmon conservationist and Chairman of Restoration of Atlantic Salmon in America, Inc., was appointed as Vice Chairman of the North American Commission.

NASCO seeks to promote the conservation, restoration, enhancement, and rational management of Atlantic salmon stocks. It will, for the first time, bring salmon-producing and salmon-harvesting nations together for cooperatively assessing the health of the resource and for reversing the decline of salmon throughout the North Atlantic. Scientific and statistical information, scientific research, and regulatory measures will be NASCO's focus in the future.

Scientific research will provide data on salmon stocks and enable NASCO to propose regulatory measures to control the harvest of Atlantic salmon by ocean fisheries. Until such data are available, however, it may be necessary to adopt temporary measures to curb overharvest and rebuild stocks now considered by many at a crisis level.

U.S. Squid Exports to Japan Decline

The U.S. Regional Fisheries Attaché in Tokyo reports that the quantity and value of U.S. exports of squid to Japan, during January-September 1983, decreased by about 95 percent compared with the same period in 1982. The United States had shipped only 170 t of squid worth $0.3 million through September 1983, while 3,200 t of squid worth $4.3 million was shipped during the first three quarters of 1982. The Branch of Foreign Fisheries Analysis, NMFS, has been following the world squid situation for some time and believes that the primary reason for this decrease is the greatly increased squid exports to Japan by the Polish (state-owned) fishing industry. Japanese imports of Polish-caught squid were 22,400 t during January-August 1983, almost double the 11,400 t shipped to Japan during the entire previous year.

Yellowtail Flounder Fishery Reviewed

The NMFS Northeast Fisheries Center has released its 1983 assessment of the status of New England yellowtail flounder stocks which indicates a substantial increase in abundance. The fishery has responded dramatically to this increase: Landings for 1982 exceeded the 1981 figure by 60 percent and landings for 1983 were running well above 1982 levels and could reach 34,000 metric tons (t), 36 percent above the 1982 figure of 25,000 t and the highest U.S. catch since 1970.

The ex-vessel value of the 1982 catch was $26,226,000 which reaffirms the yellowtail as the nation's second most important flatfish and as one of the three most important groundfish species caught commercially on the East Coast. Increased yellowtail landings have been a boon to New England harvesters who, in recent years, have experienced greatly reduced catches of haddock.

The biology and distribution of yellowtail flounder are interesting and have had important effects on fishery trends. Off the U.S. coast, abundance is highest on the southern New England, Georges Bank, and Cape Cod fishing grounds at 15-40 fathoms. Since 1960, about 80 percent of the total landings have come from the southern New England and Georges Bank grounds. Yellowtail have also been fished in the Mid-Atlantic (off Long Island and New Jersey) and in the Gulf of Maine, although landings from these areas have been minor in comparison.

Foreign Fishing Vessels Seized

Three foreign fishing vessels were seized last fall in the U.S. FCZ (200-mile zone) for violating U.S. fishing regulations. The Japanese longliner *Kiyo Maru No. 455* was seized off the Alaskan coast on 23 October for grossly underlogging its catch of sablefish; the vessel was released on $300,000 bond pending further judicial proceedings. The Italian stern trawler *Maria Michela* was seized about 70 miles southeast of Cape May, N.J., also on 23 October for multiple violations, including underlogging of catch by 44 tons; the case was settled on 28 October with payment of a $65,000 fine. The Japanese transport *Nikko Maru* was seized in the Bering Sea on 12 November for multiple underlogging violations amounting to about 2,200 tons of fish during 1982 and 1983; the vessel was released on $400,000 bond pending further judicial proceedings. This brought to 11 the total number of foreign fishing vessels seized during CY 1983: Japan, 7; Canada, 3; and Italy, 1.

Recreational Fisheries Development Progresses

In 1982, an S-K study identified impediments to further recreational fishing

industry development. The 1983 S-K Program is funding $456,000 in projects to resolve these impediments. A national artificial reef center will guide the use and deployment of materials for artificial reef development. A guide to fishing pier funding sources and right-of-way acquisition will be produced for local governments. Charter boat marketing strategies will promote increased consumer awareness of recreational fishing opportunities.

In the Southeast, Southwest, and Northwest regions, S-K efforts focus on shifting the recreational angler's interest from popular, heavily pressured species to underutilized resources through public education programs. The Northwest will include information on the potential health risks of harvested shellfish. For additional information on recreational fisheries development contact: Richard H. Wheeler, NMFS, Industry Development Division, Washington, DC 20235.

Fishery Market News: 46 Years of Service

In 1937, the 75th Congress of the United States provided for the establishment of a Market News Service for the commercial fisheries at the request of the industry which felt such a service was vital to the successful marketing of fishery products. The New York office published the first daily report on 17 February 1938.

Thus, the Market News Service is observing its 46th year of continual service to the seafood industry. Within the first few years, as quickly as personnel could be trained and offices established, daily Market News reports were being released at four additional offices: Boston, 26 May 1938; Seattle, 1 October 1938; New Orleans, 5 January 1940; and Terminal Island, Calif., 1 August 1945.

For the first 37 years, the reports were provided free to the industry. In 1975 Federal government policy changes required a subscription fee to cover printing and mailing of the reports. Today that fee is $50 per year for a full service of 3 reports per week. A weekly summary published each Friday is available for $20 per year. This is one of the "best buys" in the seafood business. A year's worth of detailed market prices, both dockside and wholesale, receipts, port production, cold storage holdings, imports, exports, and numerous trade opportunities can be obtained for only 19¢ per business day. The cost of collecting and compiling this data is still borne by the government.

The purpose of the Fishery Market News Service is to provide current and timely fisheries information to fishermen, processors, wholesalers, retailers, government agencies, and others. These data aid in determining proper utilization of fishery products and in making decisions regarding fisheries and regulations.

Subscription rates for Fishery Market News Reports were increased as of 1 March 1984. The subscription rate for the full service (issued Monday, Wednesday and Friday) is $50 per year. The weekly summary, including the Friday report, remains at $20 per year. The rates for changing from a weekly to a full service report during a subscription year will be provided by the issuing office.

These rates are now in effect for all new subscriptions and renewed subscriptions. Persons subscribing to these reports should make checks (drawn on a U.S. bank) and money orders, in U.S. dollars, payable to: U.S. Department of Commerce, NOAA. Mail check or money order to the National Marine Fisheries Service Office below that issues the report desired: Blue Sheet, 470 Atlantic Ave., First Floor, Rear, Boston, MA 02210; Green Sheet, 201 Varick St., Room 1144, New York, NY 10014; Goldenrod Sheet, 600 South St., Room 1046, New Orleans, LA 70130; Buff Sheet, 300 S. Ferry St., P.O. Box 3266, Terminal Island, CA 90731; and the Pink Sheet, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

Mandatory Gulf Shrimp Data Reporting to Aid Fishery Management

Regulations requiring the reporting of Gulf of Mexico shrimp statistical information were implemented on 30 May 1984, reports Jack T. Brawner, Director of the Southeast Region of the National Marine Fisheries Service (NMFS) in St. Petersburg, Fla. This information will lead to better management of the shrimp fishery which will ultimately benefit the shrimp industry by sustaining resources at the highest possible levels, Brawner noted.

The regulations implement a management measure contained in the Fishery Management Plan (FMP) for the Shrimp Fishery in the Gulf of Mexico which was developed by the Gulf of Mexico Fishery Management Council under the Magnuson Fishery Conservation and Management Act and implemented by NMFS through regulations in 1981. However, this mandatory reporting section of the regulations was reserved to allow NMFS to develop a data collection system.

NMFS has now designed a statistical reporting system which essentially makes mandatory the voluntary reporting program utilized in the shrimp fishery since 1956. Although the reporting of shrimp statistical information under the voluntary program worked relatively well in the past, Brawner said, it was inadequate for purposes of management of the shrimp fishery under the FMP. Timely reporting of shrimp catch data during the fishing season has become essential to implementation of the FMP. For example, the acquisition of data is necessary for such management purposes as determining the time for the seasonal closure to shrimp fishing off Texas, evaluating the effects of the Tortugas Shrimp Sanctuary, and assisting states in the management of the shrimp re-

source when it is in their jurisdiction.

Brawner indicated that information collected under the mandatory system will be used only for management of the shrimp fishery, and will be released only in aggregate or summary form so as not to disclose the identity of the sources.

The regulations require shrimp vessel owners and operators randomly selected by NMFS in the Gulf of Mexico or adjoining state waters to provide, upon request, the following information: Name and official number of the vessel; amount of catch of shrimp by species; condition of the shrimp (heads on or off); depth fished and fishing location; person to whom sold, bartered, or traded; number, size, and type of gear; and effort and period of fishing.

The regulations require the receiving shrimp dealers and processors to provide, upon request, the following data: Fishing vessel (name and official number) or person from whom received; amount of shrimp or parts thereof received by species and size category for each trip; and ex-vessel value (by size category) of shrimp or portions thereof received. Further information is available from Edward Burgess, Southeast Region, National Marine Fisheries Service, 9450 Koger Boulevard, St. Petersburg, FL 33702 (telephone 813-893-3723).

Sea Scallops Show Continued Decline

The 1983 U.S. sea scallop research vessel survey was conducted from 26 July to 2 September 1983 using the R/V *Albatross IV* to evaluate resource abundance, age composition, and recruitment patterns in the Georges Bank, Mid-Atlantic, and Gulf of Maine. Catch-per-tow indices indicated that scallops have declined to very low levels on Georges Bank and in the Mid-Atlantic region. In both resource areas, the 1983 survey abundance and biomass indices were the lowest recorded in the 1975-83 survey time series, and were between one-third and one-quarter of the survey values observed during 1975-79. Consistent annual declines in survey abundance indices have now been noted for the past 3 years on Georges Bank and for the past 4 years in the Mid-Atlantic.

Recruitment in almost all areas remains low. The 1980 year class is not strong in any resource area. The very abundant 1979 year class, which has been limited to the South Channel region of Georges Bank, has been significantly reduced in size more rapidly than anticipated due to "mixing" of these scallops with larger scallops in the commercial landings. Accordingly, resource abundance on both Georges Bank and in the Mid-Atlantic will remain depressed through at least 1985 with recovery expected only when and if recruitment improves.

Significant densities of sea scallops were observed in survey tows on Fippennies Ledge and Jeffreys Ledge in the Gulf of Maine. Most of these scallops, however, were small with mean counts of 50-100 per pound. No large beds of sea scallops were located in any of the deep-water (>60 fathoms) Gulf of Maine areas surveyed. These results suggest that the Gulf of Maine sea scallop fishery will become more dependent on the inshore scallop resource than in past years.

ANUGA-83 Food Show Trade Leads Available

ANUGA-83, the largest food show in the world, was held 15-20 Oct. 1983, in Cologne, West Germany. Exhibitors totaling 4,883 from 81 countries had contact with 170,000 food buyers from around the world with attendance up by 21 percent over ANUGA-81. The Alaska Fisheries Development Foundation in conjunction with the National Marine Fisheries Service sponsored a U.S. seafood exhibit at ANUGA-83 which included 16 exhibit booths.

Fishery Development Foundations from all sections of the United States representing their regional seafood industries participated at ANUGA-83. Trade leads compiled by the Mid-Atlantic Fisheries Development Foundation, New England Fisheries Development Foundation and National Marine Fisheries Service are presently available to interested U.S. seafood companies. Anyone interested in receiving these export opportunities should write to: ANUGA-83, National Marine Fisheries Service, P.O. Box 1109, Gloucester, MA 01930-5309.

Pollock Handling Techniques Studied

Initial evaluations of samples prepared during a comprehensive field study last year in Kodiak, Alaska, to continue research on the proper handling, processing, and utilization of Alaska pollock indicate interesting results that will be important to the fishing industry, according to the Utilization Research Division of the NMFS Northwest and Alaska Fisheries Center.

Pollock used in this study were caught by a commercial fisherman in the Shelikof Straits and landed within 16 hours. Immediately after unloading the fish, the pollock were placed in ice, refrigerated seawater (32°F), and superchilled seawater (28°F), and held an additional 4 days in these systems.

The average length and weight of the pollock used in this study was 42.4 cm and 587 g, respectively. Interestingly, 48 percent of the pollock were 41-42 cm in length and 84 percent of the pollock were between 39 and 44 cm (15-17 inches) in length. This uniformity in size would be very important for processors if they intended to mechanically process the pollock.

Initial results suggest that pollock can be held in ice, refrigerated seawater (RSW), or superchilled (SC) seawater without appreciably affecting the functionality or sensory properties of pollock fillets. However, chemical tests indicated that undesirable changes were beginning to occur after 4 days, particularly in the RSW and SC systems, and this was reflected by the slightly lower desirability scores given the fried breaded fillet portions as well as the slight loss in functionality properties of the fillet muscle. Analysis of these samples will continue for 1 year to determine storage characteristics of the various treatments during frozen storage at 0°F.

Jerry Babbitt

Mexico Launches Extensive Marine Fisheries Research Program

The Mexican Secretariat of Fisheries (SEPESCA) has launched the most ambitious fisheries research project in Mexican history. As a result of fishery development programs, especially the $1.3 billion 1977-82 National Fisheries Development Program carried out by the Lopez Portillo Administration, Mexico has added hundreds of new vessels, improved existing ports and built new ones, and constructed many new canneries and cold stores. Much of this had been done without any detailed knowledge of the extent of the resources to be exploited. The new De la Madrid Administration was concerned about the dangers of making costly investments in fisheries without first assessing stocks. As a result, SEPESCA launched a massive research program, the Programa Nacional de Prospeccion y Investigacion de los Recursos Pesqueros de la Zona Economica Exclusiva de Mexico (PNPIRPZEE).

The new program is without precedent in Mexican research, both because of its extent and the level of coordination among the scientific community, government agencies, cooperatives, and private companies. The project is an important part of the Government's goal to diversify the fishing industry so it will not be dominated in the future by the shrimp trawl fishery, which was the case before 1976.

Some observers were concerned about the ability of Mexico's scientific community to plan and execute such a massive plan. The number of trained oceanographers and fishery biologists in Mexico has been limited and some believe that this may limit the ability of SEPESCA to carry out the program. Other observers in Mexico point out that SEPESCA may have been better advised to have conducted its major research program before launching the 1977-82 development program. The new SEPESCA administration, however, cannot be criticized for the decisions made by the previous administration, and the new research program is one of the first major fishery programs initiated by the De la Madrid Administration.

Resource Data Needed

SEPESCA officials have increasingly come to the conclusion that the efficient operation of the country's expanding commercial fishing fleet is impaired by the lack of data on the magnitude, location, and seasonal migrations of fishery stocks in Mexico's 200-mile Exclusive Economic Zone (EEZ). Mexico, like many third-world countries attempting to develop their fishing industries, has encountered great difficulty in profitably launching fisheries for tropical species. In the Gulf of Mexico, especially, Mexican offshore waters are basically tropical or semitropical and lack large, single-species schools that countries in the more temperate areas exploit so efficiently.

The warmer water supports a bewildering variety of species. Trawler catches often include a staggering variety of different fish species and sizes; this makes profitable commercial fishing more difficult. SEPESCA has now decided that it is essential to acquire detailed data on exactly what resources are available so that the utilization can be better planned. SEPESCA has also increasingly come to realize that data is needed on the complex relationship between species. SEPESCA wants to evaluate the impact of fishing effort not only on the stocks of target species, but also on species taken incidentally and even on species not taken, but which are in biological competition with target species.

Table 1.—Mexico's commercial fishing fleet, 1983.

Owner category	Vessel type	Species fished	No. of vessels
State companies[1]	Various	Various	[2]300
Joint ventures	Longliners	Billfish[3]	16
Cooperatives	Trawlers	Shrimp	3,400
Private companies	Seiners	Anchovy[4]	N/A[5]
Various	Seiners[6]	Tuna	52
Private owners	Various	Various	N/A

[1]"Productos Pesqueros Mexicanos" and "Industrias Pesqueras Paraestatales del Noroeste."
[2]About 100 additional vessels are on order.
[3]Striped marlin and other billfish are some of the main species taken, but the catch does include some other species.
[4]Sardines are also taken in quantity.
[5]N/A = Not available.
[6]Includes some baitboats.

Vessels and Institutions

SEPESCA hopes to mobilize Mexico's scientific community for this study. The most important source of data are the 15 research vessels operated by SEPESCA's research institute, the Instituto Nacional de Pesca (INP). The INP has three large research vessels (the R/V *Alejandro de Humboldt*, the R/V *Autonio Alzate*, and the R/V *Onjuku*) and 12 small BIP[1] series vessels. The INP has deployed nine of its vessels in the Pacific and six in the Gulf of Mexico for this study. SEPESCA also wants to utilize the Universidad Autonoma de Mexico's (UNAM)[2] two oceanographic vessels (the R/V *Puma* and R/V *Justo Sierra*), as well as the Navy's two oceanographic vessels and an airplane.

SEPESCA also plans to use the commercial fishing fleet of over 3,700 vessels to obtain data (Table 1). SEPESCA intends to compensate the commercial vessel owners for costs incurred during their participation in the program. SEPESCA and INP officials are aware that utilizing data from commercial fishermen raises various statistical problems, and some are privately concerned about it. SEPESCA has decided, however, that involving the fishermen in the study may return benefits such as sub-

[1]BIP stands for "Buque Investigacion Pesquera" (Fishery Research Vessel). Six BIP vessels are 74 feet long and have steel hulls; the other six are 40 feet long and have fiberglass hulls.
[2]UNAM is Mexico's largest and most prestigious university and has a marine sciences center, the Centro de Ciencias del Mar y Limnologia.

stantially expanding the scope of the study as well as giving the study a practical orientation which may be of great future value. SEPESCA is particularly interested in data on yields per unit of effort from vessels actually engaged in the commercial fisheries being studied. About 380 SEPESCA officials will work on the commercial vessels, helping to collect data.

Most data will be compiled by the INP's Mexico City headquarters and its 30 regional centers. SEPESCA also plans to involve personnel from other research centers besides the INP. Specialists from UNAM, the Universidad Autonoma Metropolitana (UAM), the Instituto Politecnico Nacional, and the Instituto Oceanografico de la Marina will also be involved in the new research program.

Focus

SEPESCA plans to concentrate on five different fisheries: Small pelagics (anchovy and sardine), tuna, miscellaneous finfish, oceanic species, and shrimp. Mexican officials claim that they have data on where small pelagic species occur in the Pacific, and plan to concentrate research on these species in the Gulf of Mexico to locate new fishing grounds there. For data on tunas, SEPESCA will rely primarily on the country's tuna fleet.

As for the miscellaneous finfish species, SEPESCA plans extensive studies of fishing gear, especially in the Gulf of Mexico, to determine the most efficient fishing strategies for the important species. SEPESCA plans studies on handlines, hooks, longlines, traps, and various types of nets. SEPESCA has plans for 15 simultaneous cruises covering all designated Gulf of Mexico research stations out to a depth of 600 m.

SEPESCA also plans extensive research in both the Pacific Ocean and Gulf of Mexico on oceanic species, especially sharks, squids, and billfishes. One of the major sources of information will be the longliners operated by the giant state-owned company, Productos Pesqueros Mexicanos. SEPESCA also hopes to utilize the shrimp data obtained in the study to improve existing management measures.

Objectives

SEPESCA plans to achieve a wide variety of goals as a result of the new research plan. Those objectives are to: 1) Identify and quantify fishery resources, 2) produce a catalog of species, 3) determine the fisheries yield in each fishing zone, 4) assess the impact of seasonal migrations, 5) determine the best fishing methods for each important commercial fishery, 6) formulate management plans, 7) set catch limits and closed seasons, 8) improve statistical systems, 9) improve SEPESCA's enforcement capability, 10) prepare a basic training program for high seas fishermen, and 11) define a new policy to enable the most efficient utilization of fishery resources.

SEPESCA began the first phase of the study a little over a year ago when 34 commercial vessels sailed from various Pacific ports to begin collecting data from 28 research stations. The program was also initiated in the Gulf of Mexico. (Source: IFR-83/111.)

INDIA STUDIES TUNA FISHERY

The Indian Government and several foreign companies have discussed possible participation in the development of India's first commercial tuna fishery. The Government would like to develop the fishery to provide a potentially important export product. Indian Government officials have discussed a tuna fishery at the Conference on Deepsea Fishing in New Delhi in 1981, at the Tuna Update Conference in Bombay in early 1983, and directly with various foreign companies during the past few years.

A Canadian consulting company based in St. John's, Newfoundland, was given partial funding by the Canadian Development Agency to complete a study on tuna resources, harvesting, and processing, and believes that the development of a tuna fishery in India's 200-mile Exclusive Economic Zone is economically viable. The consultants determined that the most promising grounds are off the Nicobar and Andaman Islands in the eastern Bay of Bengal and off the Laccadive Islands (Lakshadweep) in the southern Arabian Sea, where a coastal skipjack tuna fishery already exists. The Canadian company monitored the incidental catch of tuna by fishermen in these areas and projects an initial annual tuna catch of 750-1,000 metric tons (t) of mostly skipjack tuna (and some yellowfin tuna), and the deployment of one or two purse seiners. Currently, the Seychelles deploy the only known purse seiner in the Indian Ocean. Indian fishermen caught 22,000 t of tuna in 1981, most of it by artisanal fishermen in coastal waters.

The Indian Government has determined that a joint venture with a foreign company should be established to enable India to initiate the tuna fishery. No Indian company has the necessary expertise, but companies in several countries have expressed an interest in helping India expand its tuna fishery. Bids from fishing companies in Canada, France, and Italy have been made to the Indian Government, but no joint venture partner had yet been selected by the end of last year. A U.S. tuna company had previously discussed participating in the tuna fishery development with the Indian Government, but reportedly did not bid on the current venture. Some observers doubt the potential for a tuna fishery off the Nicobar, Andaman, and Laccadive Islands and are skeptical about the viability of investing in a new tuna fishery given the currently depressed world market for tuna.

If this tuna venture is successful, the Indian State Trading Corporation will freeze most of the tuna catch for export. The Canadian consultants believe that processing and canning tuna for export could eventually be profitable. The cannery's viability, however, would require a marketing relationship with an established company willing to sell the canned product under an existing label. Some of India's traditional markets for meat and marine products in the Middle East might also import tuna products. (Source: IFR-83/121.)

Japan's 1983 Fishery Imports A Record High

Japanese imports of fishery products in 1983 were 1,316,126 metric tons (t), a record high surpassing by 9.4 percent the previous record high of 1,202,857 t set in 1982, according to the customs clearance data released by the Japanese Finance Ministry (Table 1). In contrast to the increase in volume, the value of the imports in yen dropped to ¥ 1,003,124 million (US$4,233 million at ¥ 237 = US$1), down 4.2 percent from the 1982 import value.

Frozen shrimp imports totaling 148,627 metric tons worth US$1,270 million, led all other products both in quantity and value (see following article), and accounted for 11 percent in quantity and 30 percent in value of the total fishery imports (Tables 2, 3). Imports in three categories set a new record in 1983. These were capelins, squids, and cods (including Alaska pollock). Compared with 1982, significant gains in quantity were recorded in the imports of frozen cods (+151 percent), live eels (+58 percent), clams (+30 percent), and frozen yellowfin tuna (+23 percent), whereas sharp declines occurred in frozen skipjack tuna (−55 percent) and crabs (−24 percent). (Source: FFIR 84-4.)

Table 1.—Japanese imports of fishery products, 1974-83.

Year	Quantity (t)	CIF value (10^6 ¥)	Year	Quantity (t)	CIF value (10^6 ¥)
1974	604,141	323,239	1979	1,151,174	930,738
1975	710,414	385,529	1980	1,037,350	764,272
1976	814,516	563,468	1981	1,129,068	879,881
1977	1,045,610	657,713	1982	1,202,857	1,046,744
1978	1,012,351	674,790	1983	1,316,126	1,003,124

Table 2.—Japan's top ten 1983 fishery product imports, by quantity.

Commodity	Metric tons	Commodity	Metric tons
Shrimp[1]	148,627	Yellowfin tuna[2]	57,741
Squid[2]	101,660	Herring[1]	53,167
Salmon[2]	99,203	Bigeye tuna[2]	52,931
Octopus[2]	95,259	Capelin[1]	40,542
Cod[2]	68,084	Sea bream[2]	21,118

[1]Frozen.
[2]Fresh/frozen.

Table 3.—Japan's top ten 1983 fishery product imports, by value.

Commodity	CIF value (10^6 ¥)	Commodity	CIF value (10^6 ¥)
Shrimp[1]	300,978	Yellowfin tuna[2]	33,004
Salmon[2]	85,002	Eel (live)	32,660
Squid[2]	55,739	Bigeye tuna[2]	30,223
Octopus[2]	45,569	Crab[2]	21,353
Herring roe[3]	33,560	Herring[1]	19,408

[1]Frozen.
[2]Fresh/frozen.
[3]Frozen/salted.

Japan's 1983 Shrimp Imports Down Slightly

Japanese imports of frozen shrimp in 1983 were 148,627 metric tons (t) valued at ¥ 300,977 million (US$1,270 million at ¥ 237 = US$1), down 2 percent in quantity and 8 percent in value compared with 1982, according to the customs clearance data released by the Finance Ministry of Japan (Table 1). The import prices for the year averaged ¥ 2025/kg ($3.88/pound). In value, the frozen shrimp represented 30 percent of all the fishery products imported.

Since Japan liberalized its shrimp imports in 1961, purchases from foreign countries climbed each year except five: 1968, 1974, 1980, 1982, and 1983. Annual imports marked a thirty-seven-fold increase over 1961. Between 1961 and 1970, Mexico and Mainland China were the major suppliers of shrimp to Japan. Since 1971, however, India and Indonesia have replaced them as leading suppliers, and in 1983, they together accounted for as much as 39 percent of Japan's total shrimp imports. In the same year, Mainland China was the sixth- and Mexico the thirteenth-ranked suppliers.

Countries which supplied over 10,000 t each in 1983 were India with 36,912 t, Indonesia with 21,766 t, Australia with 11,097 t, and Taiwan with 11,052 t. Other suppliers were, in descending order of importance, Thailand with 7,541 t, Mainland China with 5,778 t, Argentina with 4,839 t, Philippines with 4,281 t, Sabah with 3,726 t, Bangladesh with 3,725 t, Vietnam with 3,536 t, Pakistan with 3,264 t, Madagascar with 2,588 t, South Korea with 2,472 t, Denmark with 2,346 t, and Hong Kong with 2,160 t. Imports from the United States were 18 t. (Source: FFIR 84-7.)

Table 1.—Japan's frozen shrimp imports.

Country of origin	Imports (t)							Import totals, 1960-83
	1960	1961	1970	1980	1981	1982	1983	
India		27	6,336	35,249	40,049	39,833	36,912	152,043
Indonesia			3,684	27,569	24,193	23,600	21,766	97,128
Australia			3,664	8,052	11,522	11,821	11,097	42,492
China, Mainland	206	450	6,247	14,501	14,954	7,252	5,778	42,485
Thailand			5,982	8,850	10,321	9,188	7,541	35,900
China, Taiwan			2,487	4,990	7,774	7,759	11,052	31,575
Pakistan			2,276	3,574	6,382	4,175	3,264	17,395
Mexico	52	2,600	7,209	3,398	3,137	3,887	3,141	13,563
Philippines			357	2,394	2,678	3,693	4,281	13,046
Hong Kong	196	303	3,951	3,684	3,270	2,700	2,160	11,814
Sabah			993	2,411	2,674	2,660	3,726	11,471
Vietnam			25	1,665	1,763	2,884	3,536	9,848
South Korea	122	175	400	2,501	2,034	2,209	2,472	9,216
Brazil			656	2,731	1,917	2,484	1,526	8,658
Malaysia			2,060	1,716	1,567	1,453	1,300	6,036
Other countries	48	502	10,818	19,971	27,490	25,798	29,075	102,334
Total	624	4,057	57,145	143,256	161,725	151,396	148,627	605,004
Average price (¥/kg)	375	618	863	1,677	1,664	2,157	2,025	

Japanese-Russian Fishing Agreement Negotiated: Port-Call Privileges Set

Japan and the Union of Soviet Socialist Republics (U.S.S.R.) reached an agreement pertaining to their respective annual catch quotas on 24 December 1983. The agreement was concluded in Moscow after 34 days of difficult negotiations and permits the Japanese to harvest 700,000 metric tons (t) of fish and shellfish in Soviet waters during 1984, a decrease of 50,000 t from the 1983 quota. In return, the Soviets are allowed to take 640,000 t in Japanese waters, a decrease of 10,000 t from 1983. The 1984 agreement represents the first time since 1979 that the 100,000 t difference in quotas has been narrowed, now to a difference of 60,000 t (Table 1).

Table 1.—Japanese and Russian reciprocal catch quotas, 1978-84, in metric tons.

Year	Japanese quota in Soviet zone	Soviet quota in Japanese zone
1978	850,000	650,000
1979	750,000	650,000
1980	750,000	650,000
1981	750,000	650,000
1982	750,000	650,000
1983	750,000	650,000
1984	700,000	640,000

Background

Soviet and Japanese fishermen have operated extensively off each other's coasts since both countries energetically promoted the expansion of their fishing industries following the Second World War. The two countries have negotiated separate agreements to govern the catch of crab, herring, salmon, and seaweed. Japanese catches off the Soviet coast totaled 1.4 million t in 1975 and 1.5 million t in 1976. Soviet fishermen also operated off Japan, catching 0.7 million t in 1976.

In 1977, both countries implemented 200-mile fishery zones, and as a result, Soviet and Japanese officials began negotiating to set reciprocal catch allocations. They have since met annually to set catch quotas and to settle other matters affecting their fishery relations. These annual meetings cover their fishing for all species except salmon and seaweed, which are still governed by separate agreements.

Salmon Pact

The salmon agreement governs Japanese fishing of Soviet-origin salmon on the high seas. The seaweed agreement is signed by the nongovernmental Hokkaido Fisheries Association and the Soviet Fisheries Ministry. This private agreement governs the Japanese seaweed harvest off the Soviet-held, but Japanese-claimed Kaigara Island, near the northeastern coast of Hokkaido (see map).

Negotiations

The normally difficult discussions between Japan and the U.S.S.R. reportedly were particularly trying in 1983. At the initial meeting on 21 November 1983 the Soviets proposed a 50 percent reduction of the Japanese quota in the Soviet zone which the Japanese considered unreasonable. The negotiations centered on the Soviet attempt to reduce Japan's allocation as well as on the Soviet demands that the Japanese grant port-call privileges to the Soviet fishing vessels and ease restrictions on Soviet bottom trawling in Japanese waters. The Japanese objected to the Soviet proposals and wanted, instead, to continue the agreement unchanged.

Table 2.—Species composition of the Japanese fishing quota in the Soviet fishing zone, 1983-84.

Species	Quota (1,000 t) 1983	1984
Finfish		
Atka mackerel	12.7	11.8
Flounder	26.6	24.8
Ocean perch	17.9	16.7
Pacific cod	34.2	32.3
Pollock	290.0	270.0
Sand lance	40.4	37.6
Saury	68.6	63.9
Shark	1.2	1.2
Tunas	6.4	6.4
Wachna cod	16.2	15.1
Other fishes	71.7	66.8
Shellfish		
Octopus	5.2	5.2
Squid	147.9	137.7
Brown king crab	0.8	0.8
Korean hair crab	0.8	0.5
Red tanner crab	2.6	2.4
Tanner crab	2.8	2.8
Shrimp	0.5	0.5
Snails	3.5	3.5
Total	750.0	700.0

Iwazo Kaneko, Japanese Minister of Agriculture, Forestry, and Fisheries, was still confident a week later about the eventual outcome of the negotiations. He told reporters on 29 November that he expected the previous year's catch quotas would be renewed. The negotiations continued without much progress, however, until 8 December when Fumio Watanabe, Director-General of the Japanese Fisheries Agency, traveled to Moscow to break the impasse in the negotiations. He told reporters that the negotiations should be completed by 21 December. His optimism was only slightly overstated as an agreement was finally reached on 24 December.

Agreement Provisions

In the 1984 agreement, the Japanese catch allocation was reduced by 50,000 t to 700,000 t, and the Soviet allocation was decreased by 10,000 t to 640,000 tons. Japan's quotas of such valuable species as pollock, saury, squid, red tanner crab, and Korean hair crab were significantly reduced (Table 2). The Soviet quota of sardine and mackerel was reduced only slightly (Table 3).

The 1984 agreement eased Japanese regulations governing Soviet fishing op-

Table 3.—Species composition of the Russian fishing quota in the Japanese fishing zone, 1983-84.

Species	Quota (1,000 t) 1983	1984
Laemonema	90.0	90.0
Pollock	10.0	10.0
Sardine and mackerel	500.0	490.0
Saury	10.0	10.0
Other fishes	40.0	40.0
Total	650.0	650.0

erations within the Japanese 200-mile zone. Japan will permit Soviet vessels to operate throughout 1984 off eastern and southern Hokkaido. The Japanese previously banned the Soviets from bottom-trawling off eastern Hokkaido from June to August and from purse seining off eastern Hokkaido from January to June. The Japanese had also previously banned Soviet bottom-trawling off southern Hokkaido from June to August.

The agreement initiated an exchange of port-call privileges for the first time. Japan will permit Soviet vessels to call at the Pacific port of Onahama, near Iwaki in Fukushima Prefecture (see map). The port-call privileges are restricted to 48 hours per vessel and limited to 70 Soviet vessels during 1984. Only 150 Soviet fishermen may go ashore at any one time, remain for no more than 5 hours, and visit only the city of Iwaki. No calls are permitted during September and October. In exchange, the U.S.S.R. will allow Japanese fishing vessels to call at the Soviet Far Eastern port of Nakhodka, near Vladivostok, on the Sea of Japan.

Prior to this agreement, the Japanese had not granted port-call privileges to any foreign fishing vessels. The Japanese had previously rejected Soviet requests for port-call privileges, except in emergencies, because of potential problems with Soviet vessels illegally fishing and conducting intelligence operations in Japanese coastal waters. The Japanese Government had also refused Soviet requests for port-call privileges because of the likelihood of South Korean (ROK) requests for similar privileges. South Korean fishermen, like Soviet fishermen, would benefit from reduced operating costs if their vessels were allowed to make port calls in Japan.

Overview

According to the NMFS Foreign Fisheries Analysis Branch, Japan's quota reduction of 50,000 t is substantial, but not so significant as to cause the Japanese to curtail the number of fishing vessels deployed in Soviet waters. Japan has not fully utilized its quotas in recent years (Table 4), taking only 70 percent in 1983.

The U.S.S.R. has utilized even smaller percentages from its quotas, taking as little as 25 percent in 1983. Observers also believe that Japanese concern about illegal Soviet fishing in coastal fisheries may be overstated and that Soviet port-calls will, in fact, have a minimal impact on Japanese coastal fisheries. (Source: IFR-84-4.)

Table 4.—Actual Japanese and Russian catches in the other country's fishery zones, by quantity (in metric tons) and percentage of quota, 1979-83.

Year	Japanese catch in Soviet zone	Percent caught	Soviet catch in Japanese zone	Percent caught
1979	555,000	74	455,000	70
1980	532,500	71	331,500	51
1981	525,000	70	208,000	32
1982	480,000	64	188,500	29
1983	525,000 E[1]	70	136,500 E[1]	21

[1]E = Estimated catch figures based on Japanese press reports.

Note: Unless otherwise credited, articles in this section are from either the Foreign Fishery Information Releases (FFIR) compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR), Language Services Biweekly (LSB) reports, or Language Services News Briefs (LSNB) produced by the Office of International Fisheries Affairs, National Marine Fisheries Service, NOAA, Washington, DC 20235.

EC 1984 Fisheries Catch Quotas Set

The European Community's (EC) Council of Fisheries Ministers, at its 30 January 1984 meeting, approved the 1984 total allowable catch (TAC) and member country quotas for the seven major species in the Community's waters (Table 1). The TAC refers to the maximum amount of a particular species which EC fishermen are allowed to catch in a given year. Quotas refer to allocation of the TAC's among the individual EC member countries.

The Council's early decision on TAC's and quotas is a sign that the EC's Common Fisheries Policy (CFP), ratified in January 1984, is working as planned. In contrast to 1983, when constant Council disagreements delayed the adoption of TAC's and quotas until December, the CFP mechanism worked smoothly in 1984 and catch quotas were established at the beginning of the calendar year. EC officials hope that future TAC's and quotas will be established long before the beginning of the year, thus enabling EC fishermen to plan their operations for the fishing year as early as possible. (Source: IFR-84/25.)

Table 1.—Total allowable catch and EC member-country quotas for 1984, by selected major species.

Species	Total EC	TAC (1,000 t) Germany	France	Netherlands	Belgium	United Kingdom	Denmark	Ireland
Cod	516	84	36	23	8	118	234	12
Haddock	193	7	19	1	2	141	19	4
Pollock	123	21	70			21	8	3
Whiting	185	4	38	9	4	79	34	18
Plaice	199	10	7	67	12	54	46	3
Redfish	70	63	2				5	
Mackerel	407	26	17	37	—	235	7	85
Total	1,693	215	189	137	26	648	353	125

Australian Fisheries and Foreign Fishing Policy

Australia has a small fishing industry despite the country's extensive coastline and one of the world's largest fishing zones. Australian fishermen harvested only about 160,000 metric tons (t) of fish and shellfish in 1982, the first significant increase since 1977 (Table 1). Exports for the 1982-83 season set a record $369 million, up 14 percent from $323 million the year before. Japan took 51 percent of the exports, by value, and the United States took 30 percent.

Fisheries harvests have been limited because Australian coastal waters do not support large fish populations—they lack nutrients and are located in predominantly tropical or subtropical regions. The country has a small population with a low annual fishery consumption rate and the demand for fishery products has not been strong enough to generate an increased fishing effort. Moreover, Australian consumers tend to prefer fish not found in local waters. Since the early 1960's, imports have supplied about 50 percent of the finfish consumed domestically.

Most of Australia's traditional fisheries are fully exploited. Various shrimp species, rock lobster, shark, southern bluefin tuna, and most species taken in the southeast trawl fishery probably cannot sustain a significantly increased fishing effort. Australian officials, however, believe that the catch of a few species could be expanded. The best prospects are for yellowfin and bigeye tuna (Coral Sea), skipjack tuna (western Pacific), jack mackerel, and squid (Fig. 1).

Table 1.—Australia's fisheries catch, 1977-82.

Year	Catch (t)	Year	Catch (t)
1977	127,800	1980	136,600
1978	122,900	1981	129,900
1979	127,700	1982	161,000

Source: FAO "Yearbook of Fishery Statistics," 1980 and 1981 (1977-81 data) and Australian press reports (1982 data).

Foreign Fishing Policy Development

The Government established the Australian Fishing Zone (AFZ) in 1979, claiming jurisdiction over all domestic and foreign fishing activities in that zone. Once this action was taken, the Government had to determine the status of fishery resources within the AFZ and the level of Australian fishing so that foreign fishermen would be allocated only those species which domestic fishermen were not fully utilizing. The data on offshore resources was limited, primarily because Australia's fishermen were not fishing extensively in waters beyond 12 miles. The Government decided that it was important to obtain catch statistics collected by foreign fishermen as they were in some cases the only existing source of data on offshore fisheries. The Government needed such data for use in determining the status of offshore stocks.

The Australian Government's foreign fishing policy allows foreign fishermen access to surplus stocks of underutilized species in three ways: through joint feasibility projects, joint fishing ventures, or through bilateral agreements. The major objective of the Government's foreign fishing policy is "Australianization," a gradual expansion of the Australian fishing industry until all foreign fishing in the AFZ can eventually be phased out.

The Government has given preference to joint feasibility projects because foreign fishermen conduct exploratory fishing and obtain resource data necessary to establish fishery management plans. The Government has attempted to restrict the other two types of foreign access until exploratory fishing has been

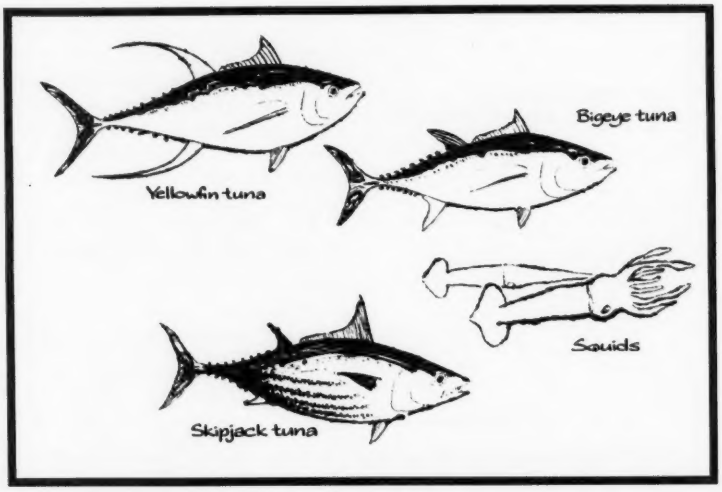


Figure 1.—Some prospects for Australian fisheries expansion include yellowfin, bigeye, and skipjack tuna, jack mackerel, and squid.

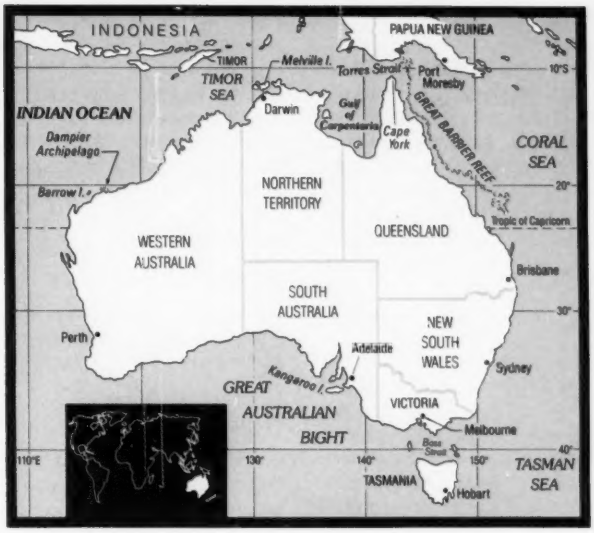
completed, but prefers joint fishing ventures because of the potential benefit to the country's fishing industry. The Government considers bilateral agreements the least preferable form of foreign access because they have the lowest potential of contributing to "Australianization."

Joint Feasibility Projects

The Australian Government conceived feasibility projects as a means of obtaining resource and economic data on a particular fishery. Under a joint feasibility project, foreign fishermen conduct exploratory fishing to obtain data on a particular fishery. Although the catch landed by foreign vessels participating in feasibility projects may be sold, a feasibility project is not strictly a commercial fishing operation. The Government has sought to promote foreign participation because its own research costs would be lessened and Australian companies would be provided reliable information on a resource's commercial potential. Australian officials could use this data to develop a fishery management plan and Australian fishermen could then make better informed decisions on investments or joint venture associations with foreign companies.

The Australian Commonwealth Government, State Governments, and the fishing industry have all collaborated in establishing regulations governing joint feasibility projects. Each project is restricted to a particular species, gear, fishing area, and port, and is usually not permitted to operate longer than 2 years. The participating foreign company must submit an interim report to the Australian authorities at the end of the first year; a more comprehensive report must be released at the end of the second year. The final report must indicate the extent of the resource, its seasonality, vulnerability to specific gear, catch rates, marketing plans, and the potential for processing the catch in Australia. The foreign partner is not guaranteed any fishing access beyond the duration of the feasibility agreement.

More than 50 feasibility proposals had been made to the Australian Government by October 1982. Most were proposed in the late 1970's after the country's fisheries jurisdiction was extended to 200 n.mi. The Australian Government has approved 22 projects deploying 113 foreign vessels. Major projects involved Japanese companies in the squid fishery off southern Australia and U.S. companies taking skipjack tuna off the east and west coasts. Other approved feasibility projects permitted Japanese, Korean (ROK), and Polish trawling operations in the AFZ.



Australia's lengthy coastline gives it one of the world's largest 200-mile fishing zones.

Japanese-Australian Squid Feasibility Projects

One of the most important and largest feasibility projects involved Japanese companies exploring for squid off the southern coast, particularly in the Bass Strait between the island of Tasmania and the Australian mainland (see map). By 1980, the Japanese were deploying 64 squid-jigging vessels, and six Australian companies had established joint feasibility projects with Japanese commercial interests.

These projects submitted reports which included the number and duration of the Japanese fishing trips, descriptions of departures from proposed operations, comparisons of catch rates with squid fisheries in other countries, operational costs and earnings, as well as information on radio reporting procedures, crew composition, and vessel specifications. In general, these reports met the requirements which the Australian Government established. However, both the Australian and Japanese partners reported a variety of problems associated with the squid feasibility projects.

Squid Export Status

Australian authorities ruled that 10 percent of the catch had to be considered Australian products. As a result, this portion of the squid catch, when landed frozen in Japan, was assessed an import tax by the Japanese customs authorities, making the product more expensive to Japanese consumers and thereby dampening the demand. The Australian and Japanese partners criticized this policy, preferring to ship squid under a Japanese label to avoid the import tax and thus increase their profits.

Radio Reporting Procedures

Japanese fishing vessels used radio frequencies which were issued under an

international radio agreement, but were not allotted to, nor used by, Australian coastal authorities. Both the Japanese and Australian partners recommended that the international radio agreement be amended to give new frequencies to a country's deep-sea vessels required to maintain contact with authorities of a coastal country. Neither the Japanese vessels nor the Australian coastal authorities had enough bilingual radio operators.

Port Calls

Japanese vessels, when calling in Australian ports, encountered additional regulations (particularly concerning piloting) which were not applied to Australian vessels of the same tonnage. The Japanese claimed that these regulations increased the operating costs of the joint ventures. Also, the Australian customs authorities confiscated certain food products on Japanese vessels and the partnerships had to buy new supplies. The crews on some vessels had to pay a customs tax on tobacco and alcoholic beverages when they came into Australian ports. Other Japanese crews, however, were not required to pay this tax. This Australian inconsistency proved especially upsetting to the Japanese fishermen and aroused considerable animosity.

Low Catch Rates

Catch rates off Australia tended to be well below the capacity of the Japanese squid vessels and below comparable Japanese squid landings off Japan and New Zealand.

Low Prices

Australian squid brought lower prices because it was smaller and was graded as being of lower quality. The Japanese also said that it tasted inferior to the squid which the Japanese took in other fisheries, particularly off Japan and New Zealand.

Limited Markets

The Australian market for squid was practically nonexistent. The few Australian consumers who purchased squid preferred Mediterranean squid or "calamari." The Japanese squid market was depressed when the joint ventures were in operation (1979-80) because of large cold storage inventories. In addition, the Japanese fishermen were catching squid elsewhere more profitably and were also importing squid cheaper from other countries. The Japanese attempted to market Australian-caught squid in Europe and Southeast Asia, but were unsuccessful.

Insufficient Resource Data

Japanese fishermen considered the 2-year agreement inadequate to determine the resource's potential.

Lack of Long-Term Fishing Privileges

The Japanese partners considered long-term commercial fishing access necessary to warrant the costs of conducting exploratory fishing and submitting resource data.

Processing Difficulties

Australian authorities permitted the Australian-labeled squid to be frozen at as little as $-20°C$, while Japan requires Japanese-labeled squid to be frozen at no less than $-50°C$. The less demanding Australian standard reportedly affected the texture, color, and flavor of the squid.

The Australian partners also criticized a few elements of the feasibility projects. The Australian observers aboard Japanese vessels encountered language problems and complained about unfamiliar food and uncomfortable living quarters. Some Australian fishermen claimed that the Japanese may have adversely affected other fishery resources in areas where they harvested squid.

Joint Ventures

The Australian Government has given the country's fishing companies considerable flexibility in negotiating joint ventures. While "Australianization" of the management, vessels, equipment, and crews is the primary objective of all joint fishery ventures, the Australian Government has not determined either the criteria for, or the rate at which this must take place. The responsibility for the implementation of the "Australianization" policy was left to the fishing industry, although the Government must ultimately approve all joint venture proposals.

The Government also has not set a minimum level for Australian equity in a joint venture company. Instead, the Foreign Investment Review Board, in the Ministry of the Treasury, must approve all equity participation plans. The Government has also done little to encourage the introduction of new fishing technology. Joint ventures do not have to deploy new vessels, use new fishing gear, or assure participation of Australian fishermen in their operations. Similarly, the Government has not approved any incentives to promote domestic construction of fishing vessels or purchases of locally produced gear and has not passed any regulations providing for the "Australianization" of fish processing or marketing operations.

A joint fishing venture is strictly a commercial operation; the same extensive statistical data submitted under a joint feasibility project are not required. The Australian Government received several joint venture proposals prior to 1980. Much of this foreign interest was probably generated as a response to the increasing number of 200-mile zone extensions by coastal countries in the mid-1970's. Polish, British, Malaysian, Japanese, and U.S. companies, among others, submitted proposals which were rejected. The Government was unwilling to approve joint commercial fishing ventures until the status of fishery resources in the AFZ was determined. The initial foreign interest seems almost nonexistent, and by August 1983, no joint ventures were operating.

The Australian experience with joint ventures has also been affected by foreign policy considerations, especially with regard to the Soviet Union and Japan. Soviet fishermen were allowed to trawl for shrimp and finfish near Barrow Island and Dampier Archipelago off the northwest coast. The entire catch was to be offered for sale to Australian companies; if any catch was not sold domestically, it would be labeled "Product of Australia" and exported. The Australian Government terminated the joint venture with the Soviet Union after that

country invaded Afghanistan in December 1979.

Bilateral Agreements

Under the third type of access, a bilateral agreement, Australia requires foreign vessel owners to pay an access fee in exchange for permission to fish in the AFZ. Australia currently has bilateral agreements with the ROK, Taiwan, and Japan. The Korean and Australian Governments signed an agreement in November 1983, allowing the Koreans to take squid. Fishermen from Taiwan have been permitted to catch various finfishes including shark since 1979. Japan and Australia signed an agreement in 1968, allowing Japanese fishermen to harvest southern bluefin tuna.

The agreement permitting the Japanese to take tuna is noteworthy for three reasons: Tuna is an underutilized species, Australian fishermen wanted to expand their own operations in this fishery, and the Japanese used economic pressure to secure access to a valuable fishery. Australian fishermen who recently made significant investments in the tuna fishery complained to their Government about the extensive Japanese fishing for tuna in the AFZ.

The Committee on Trade and Commerce of the Australian Senate issued a report in November 1982 stating that the Australian Government attempted to limit the Japanese access. The report also said that the Japanese Government maintained that a curtailment of Japan's tuna fishing would force a reevaluation of its entire commodities trade with Australia, particularly the imports of beef, one of Australia's major exports. The Australian Government backed down and was strongly criticized by the fishing industry for favoring the beef industry at its expense. In October 1983, the Australian Government renewed the tuna agreement permitting the Japanese to continue harvesting southern bluefin tuna with as many as 290 longliners.

Conclusion

The Australian Government's foreign fishing policy has not effectively channeled foreign interest in Australian fisheries into any substantial long-term benefits for the country's fishing industry. The Government's policy of requiring costly foreign commitments in joint exploratory projects, before approving joint commercial fishing ventures, has limited the interest of foreign companies. Without firm prospects of access to commercial fishing, foreign companies have been reluctant to make the necessary investments. Foreign policy considerations have also affected joint ventures. The Australian Government's decisions to safeguard Australian beef exports to Japan and to show its displeasure over the Soviet invasion of Afghanistan indicate that these issues were considered more important than the fishery issues at stake.

Australia's foreign fishing policy has not been a complete failure. The squid feasibility projects with the Japanese have produced two major benefits for Australia's fishing industry: 1) The knowledge that squid may be a commercially exploitable resource, as well as 2) information on other fishery resources caught incidentally to squid.

The squid projects, however, did not contribute to the "Australianization" of the country's fishing industry. Processing in Australia was limited because of the high charges for port calls, processing, and cold storage. Australian fishermen showed little interest in learning squid fishing techniques and were unwilling to work on Japanese vessels because of low pay, cramped living quarters, long working hours, and extended fishing trips. Similarly, Australian companies were reluctant to make significant investments in this fishery. (Source: IFR-84/8.)

Taiwan Ups Fish Imports From the United States

The value of U.S. fishery exports to Taiwan in 1983 increased by 72 percent compared with such exports in 1982, when the United States exported 2,200 t of fishery products worth $6.9 million. In 1983, shipments increased 370 percent by quantity to 10,400 t and 72 percent by value to $11.8 million.

The most valuable U.S. commodity export to Taiwan in 1983 was fish roe which accounted for $5.6 million, or 47 percent of the total value of U.S. fishery exports to Taiwan. The quantity and value of U.S. exports of salmon, sablefish, and canned shrimp to Taiwan also increased significantly in 1983. United States fishmeal exports to Taiwan in 1983 accounted for 83 percent of that total export quantity, but only 23 percent of the total fishery export value.

Japan and Portugal Extend Tuna Pact

Japanese and Portuguese representatives, meeting in Lisbon late last year, extended their existing bilateral tuna agreement, first concluded in 1980. The agreement allows Japanese tuna longliners to fish off the Portuguese mainland, the Madeira Islands, and the Azores for a specified number of fishing days (Table 1).

In return, the Japanese will train two Portuguese tuna fishermen for 1 month each, provide the services of a Japanese tuna longlining expert for 3 months, and allow Portuguese biologists to collect data aboard the Japanese longliners deployed in Portuguese waters. The Japan Tuna Federation also agreed to grant $70,000 to help the Portuguese purchase a small computer. Japanese sources report that the Japanese tuna catch (mostly bluefin and bigeye tuna) in Portuguese waters varies from 2,000 to 5,000 metric tons per year. (Source: IFR-84/6.)

Table 1.—Terms of tuna agreement between Portugal and Japan, 1980-84.

Year	Max. fishing effort[1]		Fees (US$)		Special Japanese contribution (US$)
	Mainland	Madeira	Fishing[2]	Vessel	
1980	150	1,190	0.26	N/A[3]	55,000
1981	428	1,284	0.30	N/A	N/A
1982	517	1,550	0.30	100	—[4]
1983	800	1,550	0.32	100	—[5]
1984	1,000	1,550	0.35	100	70,000[6]

[1]Effort in fishing days; data not available for Azores.
[2]Dollars per vessel ton (GRT) per fishing day.
[3]N/A = not available.
[4]The Japanese contributed a 20 GRT vessel and navigation system, but the value is unavailable.
[5]Contribution of engine parts for the 20 GRT vessel and technical assistance (services of one Japanese longlining expert and training for two Portuguese fishermen).
[6]In addition to technical assistance.

Mexico Moves to Solve Tuna Fisheries Problems

The Mexican Secretariat of Fisheries (SEPESCA) is attempting to solve the country's growing tuna problem. Debts owed foreign shipyards continue to mount while the country's tuna catch is declining.

Government officials estimate that although the Mexican tuna fleet had grown to 58 vessels with a carrying capacity of 37,900 short tons (Table 1), the tuna catch totaled only 28,100 metric tons (t) of yellowfin and skipjack in 1983, a decline of over 20 percent from the 36,800 t of tuna taken in 1982 (Table 2). The catch has been affected both by problems in marketing tuna and the 1982-83 El Niño event in the Eastern Pacific.

SEPESCA estimates that vessel owners owe 80 billion pesos (≈$450-490 million depending on exchange rate) to foreign creditors for tuna vessels ordered from overseas shipyards. Many tuna fishermen have been reporting operating losses. Many owners even lack the necessary working capital to continue fishing. Denied access to the U.S. tuna market because of the 1980 tuna embargo by the U.S. Government and unable to increase exports to other foreign markets, Mexican fishermen have had to rely on the domestic market which has proven unprofitable.

The 1982 devaluation of the peso had the impact of increasing the cost, in pesos, of the vessels ordered overseas by about 500 percent. Foreign exchange shortages further complicated the ability of the owners to meet their payments. It is difficult to buy foreign currencies in Mexico because of the country's $85 billion foreign debt. The vessel owners are, as a result, unable to make the payments to foreign creditors, even if they have pesos to buy the needed foreign currency.

SEPESCA is seeking to reverse the decline in the tuna fishery. It organized a meeting in late December 1983 of all interested parties, including Government officials, cooperative leaders, and industry representatives. SEPESCA intervened because most of the vessels ordered overseas were secured by guarantees from the Banco Nacional Pesquero y Portuario (BANPESCA). The Government offered to convert the $450 million debt to 80 billion Mexican pesos to make it possible for the shipowners to make payments on their debt. The shipowners would be given 8 years to pay off their loans with a 4-year grace period before payments have to be made. The debt would be restructured by the Fideicomiso para la Cobertura de Riesgos Cambiarios (FICORCA)[1].

Through the BANPESCA, FICORCA will assume the foreign currency notes. The boatowners would make payments in pesos to FICORCA and BANPESCA would make the foreign currency payments. The De la Madrid Administration has been working for some time with the Comite Mixto de Atun of the Comision Nacional Consultiva de Pesca to resolve the tuna problem. SEPESCA hopes that the restructuring plan will avoid a total collapse of the industry.

SEPESCA also planned to provide vessel owners with the working capital needed to keep tuna vessels fishing during 1984. Some owners had tied up their vessels and did not fish in 1983. NMFS estimates that during 1983, only about half the fleet, and often less than half, was at sea fishing at any given time. Many owners maintained that the same would happen in 1984 and that they would not have enough working capital to fish. SEPESCA plans to make as much as $40 million pesos[2] available to the owners of the large (1,200 short ton) seiners. Smaller sums will be available to owners of smaller vessels.

SEPESCA has reportedly placed only two major limitations on participation in the plan. Participating vessel owners must pledge to land an amount of tuna annually equal to 70 percent of the vessels' carrying capacity and at least 75 percent of the catch must be turned over to the Government for sale on the domestic market. The vessel owners will have to set up a repayment schedule which will then be deducted from payments for tuna landed. Currently most of Mexico's tuna is sold to state-owned companies, thus ensuring BANPESCA's ability to get its share. Special arrangements will have to be made for sales in foreign ports. Such sales, however, in 1983 were only a small part of Mexico's total tuna catch.

Mexican tuna fishermen were reportedly undecided about the Government's debt restructuring scheme. The Government opened enrollment in the plan on 18 January. As of late February, however, few vessel owners had enrolled. Other observers were skeptical that the fishermen, if they enrolled in the plan, could land 70 percent of their vessels' carrying capacity in 1984. Tuna catches in the eastern Pacific declined sharply in 1983, and there was no indication that 1984 catch rates for the international fleet are improving. Reports from Mexico, however, indicate that Mexican fishermen are reporting better results than they had during the slow 1983 start

Table 1.—Mexico's tuna fleet, 1975-83, and carrying capacity in short tons.

	Seiners		Baitboats		Total	
Year	No.	Cap.	No.	Cap.	No.	Cap.
1975	20	3,709	2	270	22	3,979
1976	25	13,860	2	270	27	14,130
1977	24	13,798			24	13,798
1978	23	13,437	2	174	25	13,611
1979	25	14,622	3	405	28	15,027
1980	46	35,162	6	705	52	35,867
1981	45	33,358	10	1,133	55	34,491
1982	43	33,900	13	1,310	56	35,210
1983	49	36,891	9	1,045	58	37,936

Table 2.—Mexico's tuna catch, 1975-83.

	Catch (1,000 t)		
Year	Yellowfin	Skipjack	Total
1975	15.3	6.8	22.1
1976	13.0	7.1	20.1
1977	17.0	3.7	20.7
1978	18.1	4.7	22.8
1979	22.3	4.8	27.1
1980	18.6	12.6	31.2
1981	41.1	26.1	67.2
1982	18.9	16.7	35.6
1983	20.1	8.0	28.1

[1]FICORCA is the Mexican Government trust (Exchange Risk Trust) responsible for refinancing foreign currency debts. It is also restructuring foreign debts in several other sectors of the economy.

[2]The Mexican peso has fluctuated widely on international markets since January 1982. The free-market rate was about 160 pesos to the U.S. dollar in early March 1984.

when many vessel owners tied up their vessels and refused to fish. SEPESCA Director of Fisheries Promotion, Garcia Leyva Lara, has projected a 1984 tuna catch of 60,000 to 70,000 tons. Other observers believe that, even if fishing improves, the fishermen will be unlikely to pay off an 80 billion peso debt in only 8 years, even with the 4-year grace period. (Source: IFR-84/19.)

South Pacific Nations Assert Marine Role

The Foreign Ministers of Chile, Colombia, Ecuador, and Peru, which make up the Permanent Commission for the South Pacific (CPPS), met in Viña del Mar, Chile on 9-10 February 1984 and signed the Declaration of Viña del Mar, proclaiming their intent to play a more active and assertive role in Pacific Basin marine and other affairs. The Declaration, signed by Jaime del Valle (Chile), Rodrigo Lloreda (Colombia), Luis Valencia (Ecuador), and Fernando Schwalb (Peru), charts a new course for the Commission which will serve as a coordinating mechanism to help member states obtain greater control over seabed resources and fisheries, as well as a tool to advance technical and economic development for the four countries.

The main thrust implicit in the Declaration of Viña del Mar is the statement that member countries intend to participate in and receive the benefits of participation in political, economic, and scientific activities in the Pacific Basin. Discussion during the conference highlighted the CPPS's achievement (stemming from the 1952 Declaration of Santiago) in establishing the principle of coastal-state control over 200-mile extended marine jurisdiction zones.

Technical working papers were prepared and topics discussed included liaison with other Pacific Basin organizations, scientific research, environmental protection, marine resource conservation, and exploration and exploitation of the seabed. The Declaration reaffirms the rights and duties of each state to protect its interests within 200-mile zones. The Ministers were also concerned about foreign fishermen operating outside 200-mile coastal zones and agreed that the CPPS Secretary General will coordinate consultations regarding conservation and optimum use of resources outside such zones.

The Foreign Ministers agreed that national authorities should work with the CPPS under the United Nations (UN) Environmental Program Regional Contingency Plan to accelerate research and technical cooperation. The Ministers reiterated the position affirmed by the Cali Declaration in 1981 on seabed resources outside national jurisdiction, and judged that close coordination with the Preparatory Commission for the International Sea-Bed Authority is essential. The Ministers agreed on immediate cooperation to advance scientific research and increase understanding of the Southeast Pacific marine environment.

The participants were particularly interested in promoting research on the El Niño event which had such a severe impact on Peru and Ecuador during 1982-83. They also agreed to increase both technical cooperation between CPPS nations and with UN specialized agencies and bilateral and multilateral sources of assistance. The CPPS is also seeking a technical agreement with the UN Food and Agriculture Organization.

Chilean Foreign Minister, Jaime del Valle, in the keynote speech at the inaugural session, suggested that the Law of the Sea (LOS) Convention brought to a close the initial stage of the CPPS's activities. The first phase changed the universal acceptance, valid for centuries, "that use and control of the seas was based on the widest freedom of access and exploitation by the mercantilist powers, to the detriment of the rights of the coastal state". The new phase of the CPPS's activities is characterized by greater coastal-state sharing in and control over marine resources.

The Foreign Ministers also stressed that greater responsibilities will accompany the benefits to be gained through development of coastal resources. Del Valle suggested that the CPPS will focus its efforts on the defense of acquired rights, marine environmental protection, preservation and optimum use of resources, and especially, modification of the CPPS to widen its field of activities to the entire Pacific Basin. The CPPS countries' joint effort will require cooperation of and contribution from regional international organizations, in the form of financing, professional training, and technology.

Del Valle said that the CPPS nations will continue to pioneer developments concerning coastal-state control over marine resources, characterizing it as a moral obligation. The Ministers found that this requires institutionalization of Foreign Ministers' meetings and more frequent and regular ordinary meetings.

Chilean President Pinochet hosted a luncheon for the Ministers after the 9 February opening session. According to press reports, Pinochet called for the CPPS to assume the responsibilities offered by the new LOS regime, and to extend its activities into new fields. He said that the historic moment calls upon the CPPS countries to "project themselves toward the immense reality of the Pacific Basin".

Colombian Foreign Minister Rodrigo Lloreda praised the Commission's earlier achievement of control over 200-mile coastal zones, and suggested that close attention be given the new LOS regime. The present problem, Lloreda said, is to consolidate the gains which have been made and to cooperate in efforts to protect the common interest. Referring to the LOS regime, Lloreda linked 18th century high seas "piracy" with 19th and 20th century fishing practices. He also said that the CPPS needs to develop a "mechanism" to protect fisheries, limit catches, and preserve species. (Source: IFR-84/21.)

Krill From Chile

Chilean officials report that they exported 2,000 tons of krill to Japan in 1983. They claim that the Chilean product is about 40 percent more expensive than krill available from the Soviets and Koreans (ROK), but is of higher quality. The Chilean company producing krill was a joint-venture with Japan. Still, krill remains a rather minor part of Chile's total seafood exports which amounted to about $375 million in the first 10 months of 1983 alone.

El Niño Blamed for 25% Drop in California Landings

California's commercial fishermen are hoping for a return to normal weather conditions this year after suffering through a warm-weather El Niño weather pattern that contributed to a 25 percent drop in landings for 1983, State officials report. Preliminary figures from the California Department of Fish and Game show a total 1983 commercial catch of 513,242,858 pounds, compared with 687,808,987 in 1982. These figures include landings in California ports of fish taken north and south of the state.

A comparable 25 percent decline was noted for the 25 leading species taken in California waters—from 456,877,393 pounds in 1982 to 343,245,778 pounds in 1983. Revenue for the same 25 species dipped from $105,468,897 to $102,238,455, a 3 percent drop. In poundage, the take of squid dropped 92 percent; anchovies, 91 percent; and salmon, 86 percent. Other notable losers were shrimp, down 74 percent; crab, down 70 percent; and rockfish, down 35 percent.

Hardest hit in the pocketbook were the salmon fishermen and the California Department of Fish and Game. Salmon fishermen saw their estimated earnings plummet from $18,841,266 in 1982 to $1,787,930 in 1983—a 90 percent drop. The Department of Fish and Game lost 25 percent of its commercial fish tax base. Fish taxes vary from $0.006 to $0.05 a pound, depending on the species.

Combined Pacific and jack mackerel landings dominated the commercial catch, both in 1982, with 121,048,046 pounds landed, and in 1983, with 107,485,464 pounds landed. Revenue to mackerel fishermen declined from $10,089,450 to $9,136,624, a comparatively modest drop of 9 percent.

Thanks to El Niño, the biggest gainers for the year were skipjack and yellowfin tuna fishermen, with landings from California waters eclipsing all previous records. Skipjack tuna jumped from tenth in the rankings to second, with a 383 percent gain. The 1983 landings were 41,453,923 pounds, up 32,879,484 pounds the previous year. Yellowfin tuna jumped from tenth on the list to third, with a 256 percent gain. The catch for 1983 was 39,478,096 pounds, compared with 11,084,567 pounds for 1982. The return to fishermen for the 1983 catch of skipjack tuna was $15,337,951, compared with $3,687,008 for the previous year. The return on yellowfin tuna was $18,949,486, compared with $5,985,666 in 1982.

In price per pound, swordfish retained its number one ranking, although that price fell from $3.02 a pound in 1982 to $2.55 in 1983. Salmon prices dropped

Galveston Bay Oyster Season Closes Early

The oystering season in Texas' Galveston Bay System was closed by 1 April to prevent the public reefs from being depleted, as Parks and Wildlife Department data showed an increase in fishing pressure this year over historic levels. The report said the numbers of oyster boats in the bay increased through February, rather than decreasing as in the past.

The last time the bay was closed was during 1978 and 1979, when biological samples indicated abundance of oysters was the lowest in more than 20 years. During the summer of 1980, crews spread 52,000 cubic yards of oyster shell over about 700 acres of reefs in Galveston Bay. The new shell enhanced each acre with about 1.5 million baby oysters, and it was expected that the surviving oysters would grow to market size by the 1982-83 oyster season.

The harvest in 1982-83 reached a record 7 million pounds. The previous record of 4.5 million pounds was in the mid-1960's. Texas officials believe that the closure of the bay in 1978-79, the enhancement activities in 1980, and subsequent favorable weather conditions all contributed to the record harvest.

Eximbank Backs Loans for Exports to Brazil

A new $1.5 billion facility to guarantee loans for U.S. exports to Brazil was started by the U.S. Export-Import Bank (Eximbank) on 1 October 1983. The facility is available through 30 September 1984. Although in place, the facility could not be utilized until negotiations in progress between Eximbank and Banco do Brazil designated the U.S. and Brazilian banks which were to extend and process loans under it.

U.S. exporters of dry salted cod are especially favored to use the facility. CACEX, the Foreign Trade Department of Banco do Brazil, has prepared a list of priority products which could be imported in Brazil under the facility and dry salted cod appears as the second item. Due to Brazil's current financial difficulties, the importation of fishery products in that country has been banned, with the exception of smoked or dry salted products. Payment for imports has been effected with 180-day letters-of-credit.

For additional information, interested U.S. codfish exporters should contact Christine Fletcher, Eximbank, telephone (202) 566-8892; or Milton Rose, National Marine Fisheries Service, telephone (202) 634-7451.

from $2.57 a pound in 1982 to $2.03 in 1983, possibly because of large supplies available from other sources.

IPHC Ups Halibut Quota to 43 Million Pounds

The International Pacific Halibut Commission (IPHC), which manages the Pacific halibut fishery on behalf of Canada and the United States, recommended to the governments of Canada and the United States this year that catch limits for 1984 be raised to 43.0 million pounds—12.4 million pounds more than in 1983. The Commission's scientific staff reported that the halibut resource is rebuilding throughout its range, and particularly in the Gulf of Alaska, and the abundance of young halibut entering the fishery also is increasing. The present decrease in incidental catch of halibut in fisheries targeting on other species has undoubtedly contributed to the stock improvement according to the IPHC. However, the Commission expressed concern that incidental catches will again increase with the developing domestic groundfish fishery unless definitive steps are taken to reduce these losses.

The Commission received regulatory proposals from the scientific staff, from Canadian and United States fishermen and processors, and from other fishery agencies. The Commission recommended to the governments the following catch limits: Area 2A (all waters south of British Columbia), 0.3 million pounds; Area 2B (the waters off British Columbia), 9.0 million pounds; Area 2C (the waters off southeastern Alaska), 5.7 million pounds; Area 3A (Cape Spencer to Cape Trinity), 18.0 million pounds; Area 3B (Cape Trinity to Unimak Island), 7.0 million pounds; Area 4A (Unimak Island to 170° W and S of 56° 20′ N, exclusive of the Bering Sea closed area), 1.2 million pounds; Area 4B (Aleutian Chain W of 172° W and S of 56° 20′ N), 1.0 million pounds; Area 4C (the Bering Sea flats N and W of the closed area), 0.4 million pounds; Area 4D (Bering Sea edge N of 56° 20′ N), 0.4 million pounds; and Area 4E (Bering Sea flats east of 168° W exclusive of the closed area), 50,000 pounds.

During 1984, the Commission will manage Area 2 on the basis of the 60-40 percent division of catch between the Canadian and United States zones. The Commission is recommending management on a biological basis for 1985. The Commission also recommended a succession of open and closed periods, as well as that fishery officers inspect the holds of halibut vessels clearing into and out of Area 4 at Dutch Harbor.

The Commission also recommended that all vessels that land halibut, including sport charter boats, be licensed annually to provide more accurate, complete, and timely information for management of the halibut fishery. The Commission's Conference Board, consisting of delegates from fishermen's groups from Oregon to the northern Bering Sea, unanimously supported continuation of IPHC as the management authority for Pacific halibut.

The Commission also recommended that the sport fishery for halibut in 1984 open on 1 March and close on 31 October as in 1983, and that the daily sport catch limit and possession limit be two halibut of any size, the same as last year. The Commission further recommended that all charter vessels that participate in the sport fishery be licensed by IPHC to provide more complete information on the sport fishery for halibut.

The next annual meeting of the Commission will be held in Vancouver, British Columbia, 28-31 January 1985. Michael Hunter was elected chairman, and Robert McVey was elected vice chairman for the coming year. Other Commissioners are Sigurd Brynjolfson, Richard Eliason, Donald McLeod, and George Wade. (Source: IPHC.)

New Halibut License System

Beginning this year, all vessels that fish commercially for Pacific halibut, including guided sport charter vessels that retain halibut, are required to have an annual license issued by the International Pacific Halibut Commission (IPHC). The license is valid for halibut fishing only during the calendar year for which it is issued. Earlier vessel licenses are no longer valid.

The new license is free, and available only from the Commission in Seattle, Wash., upon its receipt of a completed "Application for Vessel License for the Halibut Fishery". Application forms can be obtained from Customs officers and Federal or State fishery officers. In ports where Customs and fishery officers are not available, application forms may be obtained from harbor masters or halibut processors, or by written request from the Commission.

The license must be on board the vessel at all times, be available for inspection by Customs or fishery officers, or by representatives of the Commission, and is in addition to any other license required under U.S., Canadian, State, or Provincial laws. Additional information and application forms are available from the International Pacific Halibut Commission, P.O. Box 95009, Seattle, WA 98145-2009.

California Rears, Plants More Striped Bass

The effort by California's Department of Fish and Game (DFG) to enhance ocean sport fishing in Southern California continued this year with the scheduled plants of 10,000 yearling striped bass in San Diego County waters. DFG marine biologist John Duffy said 5,000 of the fish were stocked on 14 February in the San Luis Rey River and 5,000 at Mission Bay.

The 10,000 striped bass are part of a 20,000-fish allocation for Southland waters authorized this year. Ocean Fisheries Unit Manager John Sunada said 5,000 fish were planted in Alamitos Bay, Los Angeles County, on 7 February and another 5,000 striped bass in Newport Bay, Orange County, on 9 February. The four 1984 plants raised the total number of striped bass planted in Southern California ocean waters to 191,611 since the program began in 1974. The bass are raised at the DFG's Central Valleys Hatchery near Elk Grove. (Source: California Department of Fish and Game.)

Trophy Anglers Have Another Great Year

World game fish records approved by the International Game Fish Association (IGFA) during 1983 totaled 619, nearly as many as the all-time high of 633 records granted during 1982. Included were 20 new all-tackle records (heaviest catch of a species), 329 saltwater line-class records, 158 freshwater line-class records, and 112 new fly rod records (64 freshwater and 48 marine).

Record claims processed by the Association during the year numbered close to 1,000. IGFA President Elwood K. Harry attributed the continued high number of record applications to an increased awareness among anglers of the many existing record opportunities in vacant line and tippet class categories.

All-Tackle Records

Largest all-time angling records were set from Alaska to Europe, the Orient and the South Pacific. A 288-pound 12-ounce dogtooth tuna caught off Korea last October surpassed a record set in 1980 by almost 95 pounds. The all-tackle record for giant trevally was broken twice off Hawaii with fish weighing 118 pounds and 137 pounds 9 ounces. And a record 468-pound white sturgeon made angling history in California, breaking a world record of 407 pounds established in 1979; also recorded was a huge 57-pound 13-ounce carp taken in the Potomac River, Washington, D.C., and many others.

Line-Class Records

Of the 158 new world records established in freshwater line-class categories, the greatest number (40) were in the 1 kg (2-pound) line class. New records were set for 48 of the 74 freshwater species currently listed by IGFA, with 20 new marks established for various basses, 21 for salmon, and 19 for trout. Most new records were established for northern pike and chinook salmon (9 each), as well as coho salmon and lake trout (8 records each).

Saltwater line-class categories accounted for the greatest number of records during the year, 329 (108 in the 8 kg (16-pound) line-class category). Many records were also established in the "new" ultra-light line class categories, with 52 new marks in the 1 kg (2-pound) line class and 74 in the 2 kg (4-pound) category.

Records were established for 69 of the 77 saltwater species currently listed by IGFA. The most records were set for Atlantic cod (13), lingcod (12), black drum and albacore (11 each), and barracuda and Pacific bonito (10 each). Other popular species for record-setters during the year were bluefish, bonefish, crevalle jack and snook (9 records each); tarpon and Atlantic bonito (8 records each); and blackfin tuna, weakfish, permit, and pollack (7 each).

Flyrodders set 64 new records for freshwater species and 48 for marine fish during the past year. The greatest number of freshwater fly fishing records (22) were set in the 4 kg (8-pound) tippet class category, and the most saltwater records (21) were in the 2 kg (4-pound) tippet class.

New fly rod records were established for 28 different freshwater species and 23 types of saltwater fishes. Saltwater flyrodders also set five new tippet class records for red drum and black skipjack, four for spotted seatrout, and three each for dolphin, crevalle jack, pollack, and tarpon (including a 91-pound catch on 8-pound tippet).

Despite the outpouring of new record catches by anglers, IGFA foresees many new records in coming months, owing in part to the expansion of its record programs which have opened many opportunities for the average weekend angler to join the ranks of world record holders. Also, beginning this year, IGFA will be accepting all-tackle record applications for species not currently included on their record lists. For further information, contact IGFA, 3000 East Las Olas Blvd., Ft. Lauderdale, FL 33316-1616.

IGFA Sponsors First World Angling Conference

The First World Angling Conference, sponsored by the International Game Fish Association, was held in Cap D'Agde, France 12-18 September 1984. It provided, says Elwood K. Harry, IGFA President, "A unique opportunity to hear expert viewpoints on sportfishing subjects, exchange ideas with anglers and authorities from around the world, and enjoy a vast amount of fishing film presentations."

Wednesday, 12 September, was devoted to registration and orientation; the following three days featured a tight agenda of panels, speakers, and audio-visual presentations on recreational fishing and conservation. Sunday, then, saw a day-long International Fishing Film Festival when top-rated fishing films from around the world were shown. Monday was again devoted to talks and panel discussions. And, Tuesday, 18 September, was again devoted to films.

For several years the IGFA has recognized the need for such a World Angling Conference, especially in view of the environmental problems, water pollution and contamination, reduction of fishing habitat, dwindling stocks of many species, etc., as well as many management problems. Thus, this was the first global conference where such problems could be compared worldwide, and solutions to them sought.

The first conference day, 13 September, was devoted to sportfishing reports from around the world, including national fishing histories, outlooks, and problems. Session two focused on fisheries habitat, including discussions of the worldwide acid rain problem, causes and effects of fish contamination,

and ways to overcome damage to fisheries through habitat restoration.

Fisheries research was the theme of Session three. Fish tag and release programs and the role of satellites in research and management were among the scheduled topics. Session four dealt with management of recreational fisheries, including a review and evaluation of international management efforts and the role of artificial reefs in fishery management. Recreational fisheries development was the theme of the last session including discussions of the purposes and values of fishing clubs and tournaments.

California Legislature Reopens Mackerel Season

About 300 tons of Pacific mackerel landed in early April in California as purse seiners out of San Pedro returned to a fishery reopened by emergency legislation signed into law 5 April by Governor George Deukmejian. The legislation, AB 834 authored by Assemblyman Gerald Felando of Los Angeles, permitted the take of 2,500 tons of Pacific mackerel a month for the final three months of the season, April through June.

The season was closed in early February after the fishing fleet logged in a total catch exceeding 26,000 tons, 4,000 more tons than the 22,000 tons originally allocated by the Department of Fish and Game (DFG). The additional tonnage was authorized by the Department in January largely on the basis of financial hardships facing the fishermen. As provided by law, California's Department of Fish and Game sets a seasonal quota based on an amount equal to 20 percent of the Pacific mackerel in excess of 20,000 tons total population north of Punta Eugenia, Baja California.

The intent is to safeguard a fishery that has recovered remarkably from a collapse in the 1960's. In 1970, a moratorium was placed on the take of Pacific mackerel after landings during 1967-69 averaged only 1,100 tons per year. On 1 October 1977, the fishery was reopened, and mackerel landings have averaged 33,000 tons during the last five seasons. Two weak year classes, however, could be a sign that overfishing may hurt the resource. Both the 1982 and 1983 year classes appear to be unusually weak, DFG marine biologists say. They caution that overharvesting at this time could have a significant impact on the resource in future years. Biologists point to the decline of the sardine and the Pacific mackerel as two historical examples of overfishing. The bill signed into law 5 April also extended to the Fish and Game Commission the authority to raise or lower future Pacific mackerel quotas set by the department. (Source: California Department of Fish and Game.)

Oregon's 1983 Shrimp Landings Down 65%

Preliminary landings of shrimp in Oregon for the 1983 fishery totaled 6,394,000 pounds compared with 18,463,000 pounds in 1982, for a decrease of 65 percent. The 1983 Oregon shrimp season showed a maximum of 101 vessels operating during May, and a minimum of 35 vessels during September. During October the number of vessels increased to 50, and a total of 326,000 pounds were landed.

The largest volume of shrimp were found in the Cape Blanco to Cape Arago area and the Mudhole area during April. By June much of the volume was found off the coast of Washington. Landings and effort continued to remain almost entirely off the coast of Washington through the end of the season.

Texas Mullet Catch Sets State Record

Bill Fritch of LaMarque, Tex., set a state record that may never be broken when he braved the record-breaking cold weather to go fishing on 28 December at a pond near Galveston Bay's Swan Lake area. The 13.8-pound saltwater mullet he pulled in that day establishes a new category for the species in the record book. It may last a long time, according to Texas Parks and Wildlife Department officials, because mullet are plankton and algae eaters which are rarely caught on hook and line. Fritch was using a shrimp-baited treble hook, and apparently hooked the fish near its gill cover.

Fisheries Economics and Trade Conference Held

A conference on "Economic Recovery, Fisheries Economics and Seafood Trade" was held in Christchurch, New Zealand, on 19-23 August 1984. It featured speakers from private and governmental sectors and the academic communities of more than 15 countries. Discussion focused on the relationships among global economic conditions, fisheries management, and international seafood trade patterns. Cooperative research and data sharing processes were also discussed in this, the second conference of the International Institute of Fisheries Economics and Trade (IIFET).

The International Institute of Fisheries Economics and Trade was organized to promote discussion of factors affecting international trade in seafoods. Designed to be attractive to individuals from governments, industry, and universities from all over the world, a major goal of the organization is to facilitate cooperative research and data exchange. Membership in the organization is open to anyone for a nominal fee (US$10.00 annually). Further information and membership application forms are available through IIFET, Oregon State University, Corvallis, OR 97331, USA.

In addition to a series of overview papers on fisheries issues and seafood trade, conference sessions were held on the following topics: Economic recovery and seafood trade; seafood demand characteristics, import requirements, and economic recovery in selected regions; the new ocean regime (implications for harvest and trade); external debt in developing countries and seafood trade; financing seafood exports; seafood trade and fisheries management (macro vs. micro models); information exchange working group; multinational economic communities, fisheries policies, and seafood trade policies; multinational arrangements.

New NMFS Scientific Reports Published

The publications listed below may be obtained from either the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402; from the Publications Services Branch (E/AI13), National Environmental Satellite, Data, and Information Service, NOAA, U.S. Department of Commerce, 3300 Whitehaven St., Washington, DC 20235; or from the National Technical Information Service, Springfield, VA 22151. Writing to the agency prior to ordering is advisable to determine availability and price, where appropriate (prices may change and prepayment is required).

NOAA Technical Report NMFS Circular 451[1]. Matsumoto, Walter M., Robert A. Skillman, and Andrew E. Dizon. **"Synopsis of biological data on skipjack tuna, *Katsuwonus pelamis*."** January 1984, iv + 92 p., 77 figs., 20 tables.

[1]In 1983 the NOAA Technical Report NMFS series was established to replace two subcategories of the NOAA Technical Report series, the "Special Scientific Report—Fisheries" (SSRF) and the "Circular." Thus, Circular 451 is the final number published in its subcategory. SSRF 783, now in press, will be the final number in its subcategory. The new series will begin with number one again, which is NOAA Technical Report NMFS 1, "Synopsis of biological data on the blue crab, *Callinectes sapidus* Rathbun" by M. R. Millikin and A. B. Williams.

ABSTRACT

This synopsis of biological data on skipjack tuna, *Katsuwonus pelamis*, includes information on nomenclature, taxonomy, morphology, distribution, reproduction, nutrition, growth, behavior, physiology, population structure, exploitation, and management of the species. Over 600 of the more important published and unpublished reports up to 1980, including some published in 1981, were consulted.

NOAA Technical Report NMFS SSRF-779. Kajimura, Hiroshi. **"Opportunistic feeding of the northern fur seal, *Callorhinus ursinus*, in the eastern North Pacific Ocean and eastern Bering Sea."** February 1984, iv + 49 p., 38 figs., 12 tables, 13 app. figs., 1 app. table.

ABSTRACT

The Pribilof Island population of northern fur seals, *Callorhinus ursinus*, feeds on a variety of prey throughout its subarctic

The Fishes of the Upper Midwest Region

"Fishes of Wisconsin" by George C. Becker has been published by the University of Wisconsin Press, 114 North Murray Street, Madison, WI 53715, with the support of the University of Wisconsin Sea Grant Program under a grant from NOAA's Office of Sea Grant. Becker is Emeritus Professor of Biology and Curator of Fishes at the University of Wisconsin at Stevens Point.

At 1,052 pages, the volume gives thorough and comprehensive treatment to the almost 160 species of Wisconsin's waters and, indeed, will be a valuable reference for much of the upper midwest region. With thousands of lakes and miles of streams and bordering Lakes Superior and Michigan, Wisconsin's fishes and fisheries are diverse and important. The State's Lake Michigan sport fishery alone produces an estimated $30 million annually.

Far more, the book provides a geological history of Wisconsin's waters and their uses and pollution. Another chapter covers fishery research and management in the State, the role of nongame fishes in ecosystem integrity, numbers of species and general fish distribution, introduction of exotic species, and endangered and extinct species. Common fish parasites are discussed in another short chapter. The author also provides suggested management changes for fish resources that may be troubled, and his brief glacial history tells why many Great Lakes fishes are related to species of the Mississippi River basin.

Becker recognizes 157 species of fish in Wisconsin waters: 137 in the Mississippi River basin, 131 in the Lake Michigan basin, and 74 in the Lake Superior basin. The key to the families and the family keys are clear and very well illustrated. Dual trout and salmon keys are provided for adults and for young up to 125 mm. Quality of the color plates varies as some photos are of museum specimens, some of fresh specimens, and some are of drawings.

But the bulk of the volume, 783 pages, is devoted to the species accounts. Each is led off with excellent black and white illustrations of the species, scientific and common names, a thorough description of the species and data on its distribution, status, habitat, biology, importance, management, and, where appropriate, systematic notes. The author also provides original information relating to age, growth, and ultimate size of the species, as well as behavioral data dealing with prespawning, spawning, nest construction, egg care, and behavior toward the same or other species. Maps show North American distribution for the species and the range in Wisconsin. An extensive list of references is provided.

In sum, the author has drawn together virtually all pertinent data on Wisconsin's fishes and produced a comprehensive, well illustrated and easily readable volume of great value to fisheries biologists, researchers, and managers, students, and anglers not only in Wisconsin, but through much of the upper midwest. Introductory explanations of the species accounts, keys, distribution maps, abbreviations, acronyms, signs, and an extensive glossary will aid non-

range from California to the Bering Sea. A total of 53 species of fish and 10 species of squid has been identified from the stomachs of fur seals taken during 1958-74. Some fur seal prey species are commercially fished while others are not of commercial importance but are important forage food for many other predators including other marine mammals, seabirds, and fishes. The season and location are important considerations, as are the migratory characteristics of forage species, when studying the diet of fur seals in the eastern Pacific. Evidence suggests that fur seals are opportunistic feeders preying on the most available species throughout their range.

NOAA Technical Report NMFS SSRF-780. Scheffer, Victor B., Clifford H. Fiscus, and Ethel I. Todd. **"History of scientific study and management of the Alaskan fur seal, *Callorhinus ursinus*, 1786-1964."** March 1984, iii + 70 p., 14 figs.

(No abstract.)

NOAA Technical Report NMFS SSRF-781. Wass, Richard C. **"An annotated checklist of the fishes of Samoa."** May 1984, v + 43 p.

ABSTRACT

All fishes currently known from the Samoa Islands are listed by their scientific and Samoan names. Species entries are annotated to include the initial Samoan distributional record, synonyms used in earlier publications dealing with Samoan fishes, and comments relating to taxonomy, ecology, and distribution. New species records resulting from recent collections by the author and others are included. Brief diagnoses are provided for undescribed and unidentified species. The list totals 991 species representing 113 families; 284 of the species are previously unrecorded from Samoa and 38 of the entries are unconfirmed records derived mostly from 19th century publications.

NOAA Technical Report NMFS 1. Millikin, Mark R., and Austin B. Williams. **"Synopsis of biological data on the blue crab, *Callinectes sapidus* Rathbun."** March 1984, iv + 39 p., 10 figs., 11 tables.

ABSTRACT

This synopsis reviews taxonomy, morphology, distribution, life history, commercial hard and soft shell crab fisheries, physiology, diseases, ecology, laboratory culture methodology, and influences of environmental pollutants on the blue crab, *Callinectes sapidus*. Over 300 selected, published reports up to and including 1982 are covered.

NOAA Technical Report NMFS 2. Kendall, Arthur W., Jr., and Beverly Vinter. **"Development of hexagrammids (Pisces: Scorpaeniformes) in the northeastern Pacific Ocean."** March 1984, iii + 44 p., 16 figs., 13 tables, 10 app. figs.

ABSTRACT

Larvae of *Oxylebius pictus*, *Zaniolepis* sp., *Ophiodon elongatus*, *Hexagrammos stelleri*, *H. decagrammus*, *H. lagocephalus*, *H. octogrammus*, and *Pleurogrammus monopterygius* are described and illustrated from field collections which were supplemented by laboratory reared specimens of some species. Larvae hatch at a rather large

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technical readers. Hardbound, the book costs $75 and is available from the publisher.

A Guide to Lake Superior Fishes

"Fishes of Isle Royale," by Karl F. Lagler and Charles R. Goldman, is not as limited in scope as the title might imply. In fact, it is a handy, authoritative, and inexpensive field guide to common Lake Superior fishes. The authors are well-known fishery scientists with extensive experience in the region. Lagler is with the University of Michigan and Goldman is now with the University of California at Davis.

The book is a more popular version of the author's technical work and includes a discussion of fish habitats, the types of fish, and an excellent pictorial key to their identification. Also included is an annotated list of 52 species in 14 families, data on basic fish anatomy and fishery resource conservation, and a map of local fishing waters.

The 58-page paperbound handbook has been published by, is available from, the Isle Royale Natural History Association, 87 N. Ripley St., Houghton, MI 49931-1895 for $4.45 plus $0.90 for postage and handling. It is well written, attractively illustrated, and provides references to both technical papers and bulletins on fish preservation and cooking.

West Coast Clams

"Pacific Coast Clam Fisheries" by Timothy D. Schink, Katherine A. McGraw, and Kenneth K. Chew has been published as Technical Report WSG 83-1 by the Washington Sea Grant Program, University of Washington, HG-30, Seattle, WA 98195.

Annual U.S. clam harvests averaged about 100 million pounds during the 1970's, and while the Pacific Coast clam industry totals only about 1 percent of that figure, it is locally important and has potential for growth. Washington tallies about 95 percent of the region's commercial clam production and Alaska accounts for most of the rest. Oregon and California have much less habitat, and recreational clam harvesting takes most of their clam production. Alaska's lengthy coastline holds ample clam resources, but harvests are restricted by paralytic shellfish poisoning (PSP) and socio-economic factors.

Thus, this report reviews, by state, the region's principal commercial clam species, and the industry's history, current trends, and anticipated developments, plus data on recreational harvests. It also assesses industry problems in each state with harvesting and marketing, regulations and jurisdictional conflicts, management and technology, and such environmental problems as water quality, PSP, siltation, predation, and climatic conditions.

Two appendixes provide yearly data on Pacific Coast clam production and clam anatomy and biology. The 72-page paperbound volume provides a fine review of the region's clam resources and fisheries and is available from the publisher for $4.50.

size (3-9 mm), are heavily pigmented, and undergo direct development to an epipelagic prejuvenile stage. Larvae of the five genera are separable on the basis of body shape, pigmentation, and meristic characters. Larvae of the four species of *Hexagrammos*, which are quite similar in appearance, are separable on the basis of a combination of several pigmentation characters. Developmental evidence indicates that *Oxylebius* and *Zaniolepis* are similar to each other and are more similar to presumed primitive cottids than the other included genera. *Ophiodon* is dissimilar to the other four genera. *Pleurogrammus* and *Hexagrammos* have similar appearing larvae. Among the species of *Hexagrammos*, a progression of increasing larval pigmentation can be seen from *H. stelleri* to *H. decagrammus*, *H. lagocephalus*, and *H. octogrammus*.

NOAA Technical Report NMFS 3. Watson, John W., Jr., Ian K. Workman, Charles W. Taylor, and Anthony F. Serra. **"Configurations and relative efficiencies of shrimp trawls employed in southeastern United States waters."** March 1984, iii + 12 p., 12 figs., 11 tables, 8 app. tables.

ABSTRACT

Common shrimp trawl designs employed in the southeastern United States shrimp fishery are the flat, balloon, semiballoon, jib, and super X-3. Recent innovations in trawl design and rigging, including the twin trawl rigging and tongue trawl design, have improved the efficiency of shrimp trawling gear. A description of the construction techniques for the different designs indicates differences which affect gear performance. Measurements of horizontal spread and vertical opening for 76 trawl configurations indicate the relative efficiencies of the different designs. Maximum horizontal spreading efficiency was achieved by the "twin" and "tongue" trawl designs followed by the super X-3, jib, balloon, and semiballoon designs. Designs having the greatest vertical openings were the tongue and flat trawl designs followed by the semiballoon. Maximum total gape dimension was demonstrated by the "Mongoose" tongue trawl. Comparison of trawl spreading efficiency and door area with headrope length ratio indicates that a range of 70-80 inches^2 (per door) of door area is required for each foot of trawl headrope length for maximum efficiency with conventional trawl designs and 60-75 inches^2 per foot of headrope of tongue trawl designs.

Puget Sound Plankton and Coast Environment

"The Fertile Fjord: Plankton in Puget Sound" by Richard M. Strickland, published by the University of Washington Sea Grant Program, 3716 Brooklyn Avenue, N.W., Seattle, WA 98105, is the fourth in the excellent series of 14 "Puget Sound Books" that are sponsored in part by two NOAA agencies. The author has done oceanographic and planktonic research and is now a teacher and writer. Foreword is by Joel Hedgpeth.

The first four chapters provide a primer on plankton, their types, habitats, importance, and studies on them. Basic, but well written, they set the stage for nontechnical readers. Chapter 5 then delves into the phytoplankton in Puget Sound, primary production in the main basin and at sills, river mouths, shallow inlets, etc. Chapter 6 explores the Sound's zooplankton and food chain structure, synchronization, and efficiency.

Chapter 7 examines the types of pollution affecting Puget Sound—oil, pulp mill wastes, heavy metals, synthetic organic chemicals, sewage, etc.—and their effects on plankton, as well as the effects that plankton can have on pollution. Chapter 8 relates the history and effects of red tides in the Sound, and the final chapter discusses the possibilities in marine ranching and farming within the Sound.

The volume is not a field guide to plankton, but a well written and up-to-date look at the vital role of plankton in the Puget Sound ecosystem. The author provides a handy glossary and pronunciation guide; bibliographic notes are arranged by chapter. Indexed, the 145-page paperbound volume costs $8.95 and is available from the publisher.

The fifth volume in this series of books is **"The Coast of Puget Sound, Its Processes and Development,"** by John Downing, a senior scientist with a Seattle-area oceanographic consulting firm, and whose graduate studies dealt with sand transport along beaches.

Puget Sound's 2,000 miles of coastline vary widely from rugged, exposed shores in the north to more sheltered areas in the south, and from tall rocky cliffs to tidal mud flats and smooth sandy or rocky beaches. Thus, it shares many features with other temperate shores around the world. This volume provides an intensive look at the Sound's important coastal zone from its geological origins to the processes which have and are at work today on them, including glaciation, sedimentation, and wave effects, etc., all of which help determine the character and complexity of the Sound's resources. The author also describes engineering for coastal structures and how coastal development will continue to affect the Sound's aquatic resources.

In initial chapters the author traces the geological origins of the coastal zone and describes river deltas in the Sound, waves and nearshore currents, and sedimentation. Chapter 5 presents a more detailed look at beaches, including gravel-cobble beaches, coastal sediments, and other major and minor coastal features. Wave climate in the Sound—wind patterns, storm effects, and wave generation areas—is discussed in Chapter 6, while Chapter 7 examines such coastal hazards as landslides, soil liquefaction and subsidence, and oil on beaches. Chapter 8 then relates human effects on the coastal zone and progress and problems, including data on engineering for shoreline development and control of coastal erosion. Thus, the volume is an effective addition to the series. Indexed, the 126-page paperbound volume costs $8.95 and has a useful glossary and provides a bibliography of cited literature. Overall, the series has maintained a high standard of writing, editing, production, and technical accuracy. Earlier volumes in the series are "The Water Link: A History of Puget Sound as a Resource" by Daniel Jack Chasan; "Governing Puget Sound" by Robert L. Bish; and "Marine Birds and Mammals of Puget Sound" by Tony Angell and Kenneth C. Balcomb III.

To Manage the North Pacific Marine Region

"The Management of Marine Regions: The North Pacific," by Edward Miles, Stephen Gibbs, David Fluharty, Christine Dawson, and David Teeter, has been published by the University of California Press, 2223 Fulton Street, Berkeley, CA 94720. It includes contributions from William Burke, Wlodzimierz Kaczynski, and Warren Wooster.

The volume analyzes issues relating to marine fisheries, transportation, scientific research, and multiple use conditions and conflicts (especially offshore oil development and marine pollution). Such issues as military and recreational uses and unconventional energy development are mentioned only briefly. But the primary focus is on fisheries and research in the North Pacific, defined as the north temperate zone of the Pacific Ocean, ranging from about lat. 30°N to the northern extremity of the Bering Strait and from East Asia to North America.

Fisheries, say the authors, is the one major regional problem in the North Pacific, and the book reflects that emphasis. The volume is divided into five parts, and Part I, "Living Resources in the North Pacific," is the longest at 267 pages. Part II, marine transportation, runs 105 pages; Part III, marine scientific research, 37 pages; and Part IV, multiple use conditions and conflicts, runs 56 pages.

In Part I, major living resources of the region are first identified and the fisheries are briefly outlined. Then the traditional regime for international fisheries management in the North Pacific is described. Third, the region's major fisheries conflicts of the past two decades are summarized and the trends leading to unilateral extensions of coastal state jurisdiction are analyzed. Fourth, a detailed comparative analysis of the coastal state acts is presented, and fifth, the major international fisheries policy problems generated by extended jurisdiction are analyzed.

In examining marine scientific research, the authors introduce the idea of a new regional science organization, the Pacific International Council for the Exploration of the Sea, or PICES, modeled after the ICES of the North Atlantic region. PICES, which is envisioned as an organization for facilitating or coordinating, broadly, marine science research in the region, could also aid in broadening data bases for fisheries and marine science, provide a mechanism for facilitating the systematic collection of data, help coordinate fisheries research, and provide for greater international cooperation in getting and exchanging environmental and ocean use data, the authors say.

Thus, the authors believe PICES could provide a useful service to national and international fishery management in the region while helping to coordinate climate studies or data, pollution and transportation issues, and the management of multiple uses. In sum, the volume analyzes marine policy problems in the North Pacific, describes trends in patterns of ocean use, describes and explains marine use conflicts, and assesses ways that technology and jurisdictional changes have impinged upon marine policy and management.

The volume has extensive references and footnotes, is indexed, and provides nine appendixes on fisheries agreements, allocations, and conventions, and on laws on coastal zone resources. The book is the result of the North Pacific Project established in 1976 at the University of Washington's Institute for Marine Studies in Seattle and funded by the Rockefeller Foundation. It and a separate Atlas complete the Project's first phase. Thorough and well-written, the hardbound volume will be of interest to those concerned with the future and regulation of North Pacific resources. It is available from the publisher for $50. Future volumes will attempt to formulate and evaluate alternative policies, organizational networks, and criteria for achieving optimal marine resource management for the region.

One Hundred Years of Fishery Food Science

"Development of Food Science and Technology as Applied to Fish by the Government of the United States," by Maurice E. Stansby, has been published by the NMFS Northwest and Alaska Fisheries Center as NWAFC Processed Report 83-19. Stansby is well known as one of the pioneers in fisheries technology and especially in regard to his research on fish oils.

This new report traces the beginning of fishery food science and technology by U.S. Government agencies from its beginnings during the 1870's to 1970, and an appendix (B) relates Federal Government research in Seattle, Wash., between 1966 and 1983 on food science and technology as applied to fish. Appendix A lists Federal employees who were prominent in the fisheries food science studies from 1870 to 1930 and the division and branch chiefs and laboratory directors of the old Bureau of Commercial Fisheries and predecessor agencies located in Washington, D.C., from 1888 to 1970.

Part I of the report relates general chronological developments in the field while Part II details specific developments in fisheries technology by both geographical area and types of operations (composition and nutritive values of fish products, handling of fish, canning and curing of fish, fish meal and oil, oxidative deterioration of fish oils, and exploratory fishing and gear research). A number of figures show early laboratories and field stations, and experimental equipment. Further information is available from the author, Maurice E. Stansby, Northwest and Alaska Fisheries Center, 2725 Montlake Boulevard East, Seattle, WA 98112.

The Cultivation of Salmonids

"The Salmon Handbook" by Stephen Drummond Sedgwick, subtitled "The life and cultivation of fishes of the salmon family," has been published by Andre Deutsch, 105 Great Russell Street, London, England WC1B 3LJ. Drummond, who has also authored the "Trout Farming Handbook" and is the

former Chief Inspector of Salmon and Freshwater Fisheries for Scotland, is a fish culture consultant.

The author sees the future of salmon ranching as both attractive and exciting, but "clouded by failure of nations to manage or regulate marine harvests," and he considers that salmon offer the best economic return for aquatic farming in the cooler waters of the world.

The first few chapters provide a brief and basic overview of the biology, habitat and ranges, behavior, identification, reproduction, biological needs, senses, etc., for various salmon, trout, and charrs. Chapter 5 takes a look at the rainbow trout, several charrs, and the coho, Atlantic, and pink salmon from the fish farmer's point of view. Chapter 7, "Oceans, Seas, and Lakes," discusses those salmonid habitats and then delves into the basic hydrographic features that pertain to location of marine salmon farms.

The planning of salmon farm facilities, both freshwater and saltwater, is reviewed in Chapter 8, while Chapter 9 deals with the feeding and nutrition of salmonids. Basic fish husbandry —stock selection, its improvement, and hatchery practices—are treated in Chapter 10. Salmonid diseases and their control and hatchery hygiene are discussed in Chapter 11 while Chapter 12 deals specifically with the elements of salmon ranching. Finally, economics—markets, costs, and profits—of salmon ranching are discussed in Chapter 13. A rather lengthy bibliography is categorized by subject. In sum, the author provides a well-rounded overview of the various salmonids, their biology, habits, and culture. Indexed, the 247-page hardbound volume is available from the publisher for £12.95.

A Basic Guide to Ropes

Publication of **"Fibre Ropes for Fishing Gear"** by Gerhard Klust has been announced by Fishing News Books Ltd., 1 Long Garden Walk, Farnham, Surrey, England. The volume is an FAO Fishing Manual, as is the author's previous "Netting Materials for Fishing Gear." There is some overlap between the two, but generally they are complementary.

The author provides comprehensive coverage of both vegetable (natural) and synthetic fibers; steel wires are discussed only as a component of combination ropes.

The first two chapters are relatively short and introduce technical terms and definitions and the natural and synthetic fibers and rope yarns employed by fishermen. The third chapter details the manufacture and construction of laid ropes, braided ropes, and parallel filament ropes and the finishing operations before delivery (marking, preservation of natural fiber ropes, and special treatment of synthetic fiber ropes).

Properties of the ropes are discussed in Chapter 4, including sizes, breaking strength and length, elongation, elasticity, and toughness, as are the influences of twist, and use on ropes. Also covered is the effect of wetting, light, temperature, and chemicals on the different ropes' properties and their resistance to abrasion.

Chapter 5 covers the materials, construction, and properties of fiber-steel combination ropes. Chapter 6 provides basic rules and guidance on the handling and care of fiber ropes—coiling (and kinking), whipping, knotting, and splicing—types of damage, and proper methods of storage. Finally, the selection of fiber ropes, in view of cost, length of service, properties, environmental conditions, and types of fishing is discussed in Chapter 7. Examples are also given for rope selection for various gear types.

Well illustrated, the volume provides many tables of fiber properties for comparison purposes and should be a good reference for fishermen and net makers. The 200-page paperbound book is not indexed, but provides many references, and is available from the publisher for £9.50.

Other Publications

Copies of the publication **"Basic Information on Fisheries Joint Ventures:** The Transfer of U.S. Caught Fish to Foreign Flag Processing Vessels" are now available. This pamphlet answers the questions most frequently asked about joint ventures when raw U.S.-caught fish are transferred to foreign flag processing vessels under the MFCMA, 16 U.S.C. 1801 et seq. To obtain a copy send a self-addressed, 9×12" envelope, stamped with $0.37 postage, to National Marine Fisheries Service, P.O. Box 3266, Terminal Island, CA 90731.

The Mid-Atlantic Fisheries Development Foundation has recently published a book entitled **"A Basic Guide to Exporting Seafood."** The 112-page looseleaf notebook sets forth a step-by-step approach to exporting seafood products. The guide costs $35 and can be ordered from the Mid-Atlantic Fisheries Development Foundation, 2200 Somerville Road, Suite 600, Annapolis, MD 21401.

The U.S. Embassy in Caracas has prepared an 11-page report on **"The Venezuelan Fishing Industry."** The report has sections on fisheries catch, tuna fishing, shellfish, fishing fleet, the significance of the fishing industry in the national economy, government involvement, and international fishery relations. It also includes four statistical tables. A copy can be purchased for $7.00 by ordering Report PB-84-155043 from NTIS, the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

Brazilian fishermen caught 1.1 million t of fish and shellfish in 1982, over a 30 percent increase from the 0.8 million t taken in 1981. Exports in 1982 reached a recorded $162 million, a 3 percent increase over the $157 million exported in 1981. Catch data for 1983 was not yet available, but exports will be substantially below the Government's goal of $200 million, largely because of declining lobster shipments.

The U.S. Embassy in Brasilia has prepared a 40-page report on **"The Brazilian Fishing Industry."** The report includes sections on foreign trade, cod, shrimp, lobster, shrimp culture, catfish, the IADB fisheries loan, U.S.-Brazil relations, and vessel leasing as well as 20 statistical tables. A copy of the report can be purchased for $8.50 by ordering report number PB-84-156843 also from NTIS.

Editorial Guidelines for the *Marine Fisheries Review*

The *Marine Fisheries Review* publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under a completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, the *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Cited

Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, and the year, month, volume, and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8 × 10 inches, sharply focused glossies of strong contrast. Potential cover photos are welcome, but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 50 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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